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ORIGINAL ARTICLES.

I.—Notes on an Expedition to the Fayûm, Egypt, with Descriptions of some New Mammals.

By C. W. Andrews, D.Sc., F.G.S.

IN the following note I propose to give a brief account of the chief results obtained during an expedition to the Fayûm in the early part of the present year (1903). The localities in which collections were made lie to the north of the lake Birket-el-Kerun, and are almost the same as those examined on previous occasions. Practically nothing was found in the Middle Eocene beds, but from those of Upper Eocene age a fairly large collection of vertebrate remains, including several new forms, was obtained. A few interesting things were also found in the Quaternary lake-beds in the neighbourhood of Schweinfurth's Temple (Qasr-es-Sagha); these will be referred to more fully below.

In the Upper Eocene bed the commonest forms appear to be *Palæomastodon* and *Arsinoitherium*. Of the former the greater part of a skull was found, showing that in cranial structure as well as in the teeth this animal was a far more generalised mammalian type than the later elephants. For instance, although the occipital region closely resembles that of the elephant in essential points of structure, nevertheless the enormous development of cellular bone which gives the posterior portion of the elephant skull its peculiar and characteristic appearance, has only just begun, and the temporal fossæ are only divided from one another by a high sagittal crest which extends forward to a point a little behind the orbits. The *basis cranii* and the facial region of the skull are much more prolonged than in the elephant, though here again there are no differences in essential structure. Another peculiarity noticed in the remains of *Palæomastodon* is the great variability in the dimensions, even among adult individuals. When it is remembered that this animal is probably the transitional stage between the small *Mœritherium*, about the size of a tapir, and the large longirostrine Mastodons, this variability in size is particularly interesting as

supplying the basis upon which selection could bring about a rapid increase in the dimensions of these early proboscideans, and, indirectly, give rise also to the remarkable series of changes (described elsewhere) which culminated in the production of that characteristic structure in this group, viz. the prehensile trunk.

This year remains of *Mœritherium* have been found in the Upper Eocene, a fine skull having been collected by Mr. Beadnell and a good set of lower teeth by me. It is probable that the species is distinct from those found in the beds below, in which, it should be noted, no trace of *Palæomastodon* occurs.

A considerable series of remains of *Arsinoitherium Zitteli*, Beadnell,[1] was obtained, one of the most important specimens in the whole collection being a fine skull and mandible, the first, as far as I am aware, that have been found in actual association. Furthermore, evidence of the existence of two other species of the genus has been discovered. One of these was a much smaller form, and is represented only by a portion of the upper dentition, but the other was a considerably larger animal. For instance, the dimensions of a fine left ramus of the mandible are in the proportion of about four to three of those of the mandible of *A. Zitteli*. The teeth in this jaw are excellently preserved, and the premolars present some peculiar features. The maxillary teeth as well as some vertebræ and limb-bones of the same individual were also collected.

The occurrence of a large Hyracoid belonging to a new genus (see description below) is noteworthy. Already two species named *Saghatherium antiquum* and *S. minus* have been described,[2] and I am acquainted with fragmentary remains of at least two other species, one of which belongs to a third genus. The presence of five Hyraces in these beds indicates that these animals must at that time have been an important factor in the fauna, and that the comparatively small members of the group now existing are the degenerate descendants of a once important stock. At least, one large species, *Pliohyrax græcus*, is known to have persisted till the Lower Pliocene, and has been found in beds of that age in Samos and Pikermi. As remarked below, the Egyptian species are already similar to the recent forms both in the structure and arrangement of their teeth, so that we seem as far as ever from finding a clue to their exact relationship to other ungulates.

The mandibular ramus of a large Creodont is described below and referred to a new species of *Pterodon*. It is worthy of note that *Ancodus* and *Pterodon* seem to be the only two genera of mammals found in these beds (so far as at present known) which also occur in pre-Miocene beds in Europe. Fragmentary remains of at least two smaller species of Creodonts were also found.

No new Reptilia were found, and the only specimen of value collected was a fairly complete carapace and plastron of the gigantic

[1] "A Preliminary Note on *Arsinoitherium Zitteli*," by H. J. L. Beadnell, Survey Department, Cairo, 1902.

[2] "A Preliminary Note on some New Mammals from the Upper Eocene of Egypt," by C. W. Andrews & H. J. L. Beadnell, Cairo, 1902.

land tortoise *Testudo ammon*, a preliminary note[1] on which by Mr. Beadnell and myself has lately appeared.

Several visits were paid to the lake-beds in the neighbourhood of Schweinfurth's Temple (Qasr-es-Sagha) and Dimé (see map given by Beadnell on p. 55 of this volume), and numerous flint implements such as have been recently described[2] from this locality were collected. In the same beds as these a femur and a posterior molar of an elephant were also found. The femur is that of a very large individual; it is incomplete at its upper end, the neck having been weathered away. Its length when whole was approximately 134 cm. (4 ft. 5 in.), and the diameter of the narrowest part of the shaft 39·5 cm. (15½ inches); the diameter of the head was about 17·5 cm. All the characters of the bone point to its belonging to *Elephas africanus*, a conclusion confirmed by the tooth, which is a much worn (?) last molar. The occurrence of elephant remains in this locality associated with the flint implements is important, both as extending the known range of the African elephant and also as supplying a strong reason for regarding the implements as being of prehistoric age. Dr. Budge informs me that no representation of the elephant occurs on any of the early Egyptian monuments, which certainly would not have been the case had the artists been familiar with the animal, and it therefore seems that it became extinct in Egypt at some prehistoric period, when also the implements accompanying its remains must have been made. In these beds also bones of *Hippopotamus* are very common, and those of antelopes fairly numerous; a horn-core of a species of *Bubalus*, probably *B. lelwel*, was found; remains of this species have been found in tombs at Abadiyeh.

The physical conditions of the district when the lake spread over a much larger area than at present must have differed considerably from what we now see. In addition to the widespread occurrence of remains of a thick growth of tamarisk bushes, in some places considerable areas are covered with the stumps of fossilised trees, sometimes of fair size.

Description of two New Species of Mammals.

One of the most interesting finds made on this occasion is the left maxilla, with the teeth, of a very large hyracoid mammal which must have been about the size of a large tapir. The maxillary teeth (including the canine) form a continuous, slightly curved series, and increase regularly in size from before backwards. The most notable character of the cheek-teeth, as a whole, is the presence of a well-defined channel for the reception of the crowns of the mandibular teeth, running from end to end of the molar and premolar series, and dividing their crowns into approximately equal inner and outer portions. Part of the outer side of m. 1 and 2 and nearly the

[1] "A Preliminary Notice of a Land Tortoise," by C. W. Andrews & H. J. L. Beadnell, Survey Department, Cairo, 1903.

[2] H. J. L. Beadnell, "Neolithic Flint Implements from the Northern Desert of the Fayûm, Egypt": Geol. Mag., Dec. IV, Vol. X (1903), p. 53, Pls. III–IV.

whole of the outer half of p.m. 4 are broken away; the portions missing are left unshaded in the figure.

The crowns of the brachydont molars are quadrate in outline; their outer wall is formed by a W-shaped ectoloph composed of the following elements:—a large and prominent parastyle (*p.*) and mesostyle (*ms.*) and a less-marked metastyle (*mt.*) united by V-shaped paracone (*pa.*) and metacone (*me.*). On the posterior face of both the parastyle and mesostyle is a small but well-defined tubercle, marked × in the figure; these tubercles seem to belong to the cingulum. The inner half of the tooth is composed of two tubercles, the protocone (*pr.*) and hypocone (*h.*), which give a V-shaped pattern in wear, and the anterior arms of the V's, which are the longer and may include traces of the protoconule and metaconule respectively, run outwards towards the parastyle and mesostyle. In the last molar only there is a small hypostyle (*hy.*). M. 2 and m. 1 are similar to m. 3, except for the absence of the hypostyle and their smaller size.

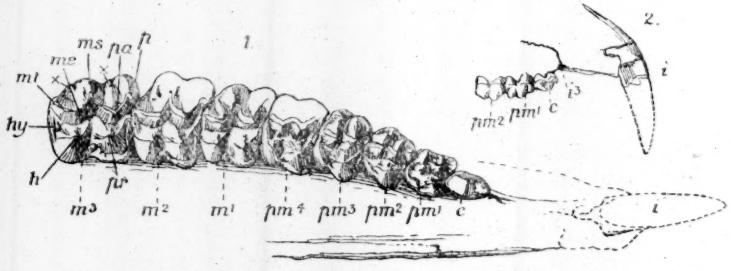


FIG. 1.—Upper dentition of *Megalohyrax eocænus*, gen. et sp. nov. The premaxillary region with the incisor (*i.*), shown by dotted lines, is provisionally restored from a premaxilla referred to in a former paper as possibly that of *Phiomia*. One-third nat. size.

FIG. 2.—Front of upper jaw of *Saghatherium antiquum*, And. & Bead., showing enlarged incisor. One-half nat. size.

c. canine; *h.* hypocone; *hy.* hypostyle; *i.* first incisor; $i.^3$, third incisor; $m.^{1-3}$, molars; *me.* metacone; *ms.* mesostyle; *mt.* metastyle; *p.* parastyle; *pa.* paracone; $p.m.^{1-4}$, premolars; *pr.* protocone.

In the fourth premolar the outer half of the tooth is broken away, but the inner portion is well preserved. This tooth differs from the first molar in the much smaller size of the hypocone (using the same nomenclature as for the molars), which is reduced to a small cusp situated on the extreme postero-internal border of the tooth. In p.m. 3 the hypocone is still smaller, and in p.m. 2 it is entirely absent. P.m. 1 is relatively more elongated than p.m. 2, the protocone is smaller, and there is a small postero-internal cusp on the cingulum which may represent the hypocone. In the premolars the ectoloph seems to consist of the parastyle, the paracone, and the metacone only; but in the posterior premolars there is a small cusp on the cingulum which may represent the mesostyle.

The canine is an elongated two-rooted tooth immediately in front of the anterior premolar and in the same line. Its crown consists

of a single low cusp, on the inner side of which there is a fairly well-developed cingulum. There is no distinct alveolus for the third incisor immediately in front of the canine, as in *Saghatherium* (Fig. 2).[1]

Comparison of the dentition just described with that of the much smaller *Saghatherium antiquum* shows that in nearly all important points in the structure of the teeth the two agree; on the other hand, the absence of the incisor in front of the canine, as well as the much greater size, seem to justify the generic separation of this species, for which the name *Megalohyrax eocænus* is proposed.

The discovery of this large Hyracoid throws much light on several doubtful fragments previously collected by Mr. Beadnell or myself. For instance, there is little doubt that the remarkable premaxilla bearing a long pointed tusk, triangular in section, provisionally referred to *Phiomia* in the paper above cited, belongs to the present species, and in the figure I have had it sketched in in outline to show its probable position with regard to the maxilla here described (Fig. 1). The reason for adopting this view is that in

Fig. 3.—Right ramus of mandible of *Pterodon africanus*, sp.n. *s* marks posterior end of symphysis. One-third nat. size.

a specimen of the upper dentition (Fig. 2) of *Saghatherium antiquum* in the British Museum the front of the premaxilla is occupied by a precisely similar tusk-like incisor (*i.*); and since, as already mentioned, the molars of this species are closely similar to those of *Megalohyrax eocænus*, it is at least probable that the latter also possessed a similar tusk, a supposition fully confirmed by the occurrence in the same beds of the remarkable specimen referred to, which corresponds both in size and form to what might be expected to have existed. It should be noted that these tusk-like incisors, both in shape and in the arrangement of the enamel, agree closely with those of *Procavia dorsalis*,[2] and it is a very remarkable fact that this peculiar specialisation of the incisors in the Hyracoidea had already arisen in the Upper Eocene.

[1] "A Preliminary Note on some New Mammals from the Upper Eocene of Egypt," by C. W. Andrews & H. J. L. Beadnell, Cairo, 1902.

[2] That is to say, that the tooth is long, curved, and grows from a persistent pulp; in section it is triangular, one of the angles being anterior. The two anterior faces only are enamel covered, and the tooth wears to a sharp point.

The dimensions of the type-specimen (Fig. 1) are :—

	Length.	Width.
m. 3	37 mm. ...	35 mm.
m. 2	37 ,, (approx.)	32 ,,
m. 1	30 ,, ...	25 ,,
p.m. 4	— ...	19 ,,
p.m. 3	25 ,, ...	21 ,,
p.m. 2	23 ,, ...	18 ,,
p.m. 1	18 ,, ...	18 ,,
c.	18 ,, ...	12 ,,

Total length of the molars	86 mm.
Total length of the premolars	76 ,,
Total length of the cheek-teeth, including the canine	178 ,,

Another interesting new species is a large Creodont, the type-specimen (Fig. 3) of which is the greater part of the right ramus of a mandible, about the size of that of a large bear. The molars and the last three premolars are in a perfect state of preservation, but the first premolar, the canine, and two incisors are represented by their empty alveoli only. Anteriorly the bone is complete, but posteriorly it is broken off about an inch behind the last molar. The symphysial region extended back to the level of the front of p.m. 3 (Fig. 3, *s*), and is very massive owing to the great size of the canines. The ramus remains nearly the same depth throughout its length, widening only very slightly beneath the hinder molars. The last molar, which is the largest of the series, is a high-crowned cutting tooth composed of two blade-like cusps and a small talon. The posterior of the two cusps is the higher, and it bears a sharp keel-like ridge on its postero-internal surface; on the antero-external surface of the anterior cusp there is a small tubercle which seems to belong to the cingulum. M. 2 is similar, but has a larger talon with a cutting edge. The first molar, which is the smallest of the cheek-teeth, is also generally similar, except that the main cusps, which are much worn, seem to be less compressed. P.m. 4, which is much larger than m. 1, consists of a large conical, rather backwardly directed main cusp, with a sharp keel-like cutting edge on both its anterior and posterior borders; behind this is a small talon, and on the whole of the inner side of the tooth there is a fairly developed cingulum, which rises into a small cusp both in front and behind. In p.m. 3 the main cusp is shorter and blunter than in p.m. 4, and the talon is smaller. P.m. 2 consists of a single cusp, the anterior border of which is much shorter than the posterior. The first premolar is represented by a small alveolus only.

The canine must have been very large, and was oval in section. There were two incisors, which, in consequence of the large size of the canine, do not stand side by side in the usual manner, but are placed one above the other in a vertical plane.

There are two large foramina on the jaw, one beneath p.m. 4, the other beneath p.m. 3. In addition to these there are also two small nutrient foramina in the inflated sides of the canine alveolus.

The dimensions of this specimen (Fig. 3) are :—

	cm.
Total length of the specimen as preserved	23·8
Length of the symphysis	8·6
Depth of the ramus opposite the hinder end of the symphysis ...	5·5
Depth of the ramus beneath m. 2	5·8
Depth of the ramus beneath m. 3	5·7
Transverse diameter of the canine alveolus (approximate)	2·0
Antero-posterior diameter of the canine alveolus (approximate) ...	2·7

Dimensions of the teeth:

	Length.	Width.
p.m. 2	23 mm. ...	11 mm.
p.m. 3	26 ,, ...	13 ,,
p.m. 4	26 ,, ...	13 ,,
m. 1	21 ,, ...	10 ,,
m. 2	28 ,, ...	14 ,,
m. 3	34 ,, ...	17 ,,

This animal closely resembles *Pterodon dasyuroides*, De Blainville, described and figured in detail by Filhol and Gervais, and may be referred to the same genus. On the other hand, its large size entitles it to specific distinction, and the name *Pterodon africanus* may be suggested for it.

II.—On the Structure of the Palate in the Primitive Theriodonts.

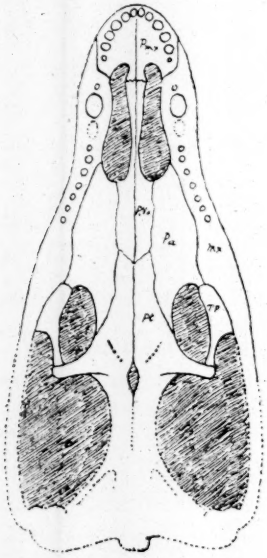
By R. Broom, M.D., B.Sc., C.M.Z.S.

FOR some years it has appeared to me that in the Order Theriodontia as generally accepted there were included a number of forms not at all nearly related to the typical genus, *Galesaurus*, and in a number of papers I have referred to these as 'Primitive Theriodonts.' The best known genera are *Ælurosaurus* and *Ictidosuchus*, but as in neither of these have the details of palatal structure been very clearly made out, it has been impossible to say how far they differed from the typical Theriodonts.

Having recently, at the request of Mr. W. L. Sclater, made an examination of some of the reptilian fossil remains in the South African Museum, I came across one or two interesting small Theriodont skulls that had been for many years in the Museum. These will be described in detail in the *Annals* of the Museum; but as one of the skulls, when developed, shows the almost perfect palate, I have thought it advisable to issue this short note on the subject, as the discovery fills a most important gap in our knowledge.

The little skull which bears some resemblance to *Ælurosaurus* I have named *Scylacosaurus Sclateri*. While there is nothing remarkable about the structure of the skull as viewed from above or the sides, the dentition is interesting. In each premaxillary bone there are six incisors, of which the last is very small. Each maxillary has a large tooth near the front, which is evidently a canine. It is not, however, the first of the maxillary teeth, as in front of it, and undoubtedly implanted in the maxillary bone, is a small pointed tooth. I regard this minute tooth as the 1st canine and the large tooth as the 2nd canine. There is evidence of a third

tooth, as yet immature, as large as the second, and which I regard as the 3rd canine. Behind the 3rd canine are seven small simple molars. A minute canine in front of the large canine is figured by Owen in *Gorgonops*, and it also occurs in another genus (*Ictidosaurus*), which I am describing.



Restoration of Palate of *Scylacosaurus Sclateri*. × ·45.

Mx, maxilla; *Pa*, palatine; *P.mx*, premaxilla; *Pt*, pterygoid; *P.vo*, prevomer; *T.p*, transpalatine.

The palate is quite unlike that of *Galesaurus* and *Cynognathus*, and is only a slight modification of that found in the Rhynchocephalians and most other primitive reptiles. It will be more readily understood by reference to the Figure than by description. The internal nares are situated well in front, and divided by the paired 'vomers,' or, as they perhaps had better be called, prevomers. These prevomers are of considerable size and form a large part of the hard palate, and articulate posteriorly with the pterygoids. The palatines articulate with the maxillaries along a line a little to the inside of the molar teeth, and partly enter the posterior border of the internal nares. The pterygoids are of large size. In front they pass forwards between the palatines to meet the prevomer, and form a large part of the hard palate. They have well-developed transverse processes, which are supported by rather slender transpalatines or ecto-pterygoids. The posterior part of the palate is unknown, but is probably as restored in the Figure.

As the palate of *Scylacosaurus* and its allies differs so very greatly from that of the typical Theriodonts I have proposed to constitute

a new order — the Therocephalia — for the primitive Theriodonts. There are many other points of difference between the two groups which I have dealt with in the paper above referred to.

Not improbably the Theriodonts proper are descended from the Therocephalians, but the gap between the two is probably as great as between Parasuchians such as *Phytosaurus* and the Crocodiles.

III.—On the Lower Jaw of a small Mammal from the Karoo Beds of Ariwal North, South Africa.

By R. Broom, M.D., B.Sc., C.M.Z.S.

IN the collection of Mr. Alfred Brown, of Ariwal North, which I had recently the pleasure of looking over, I came across the right lower jaw of a small mammal which Mr. Brown had discovered in sandstone near Ariwal. Though unfortunately the teeth are lost, there is evidence of there having been a large canine. The most remarkable character of the jaw is its extreme shortness, and in its general proportions it agrees much more with the jaws of some of the small carnivorous Eutherians than with those of the small carnivorous or insectivorous genera already known from the Secondary rocks. The angle is well developed and but very slightly inflected. The condyle is practically in a line with the alveolar margin.

Lower Jaw of *Karoomys Browni*. Nat. size.

In the absence of the teeth it is impossible to say much regarding the affinities of the genus. It is not improbable, however, that it is a member of the primitive mammalian group which gave rise to the Marsupials on one hand and the Eutherians on the other. Its nearest known allies are probably to be found among the Jurassic forms such as *Diplocynodon* or *Docodon*.

I propose to call the new form *Karoomys Browni*, after the discoverer, who has already enriched science by the discovery of so many new forms.

IV.—The Minerals of some South African Granites.[1]

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

PLUTONIC rocks of acid composition are very extensively developed in Africa south of the Equator. These rocks present many features of interest, and, especially under the microscope, many minerals may be recognized besides the usual quartz, felspar, and ferromagnesian constituents. Thus the granite

[1] Read before the South African Association for the Advancement of Science, April 28th, 1903.

of Cape Town itself is remarkably rich in accessories. Tourmaline, in particular, is very abundant in places. In thin sections it is of a yellowish brown colour frequently bordered and zoned with pale blue, while some crystals show alternate bands of yellow and brown. Cordierite also appears to be sometimes present in the normal granite. It may be quite fresh and almost indistinguishable from quartz, while in other cases it is entirely replaced by the yellowish micaceous 'pinite' pseudomorphs. The intermediate stages of the alteration are well shown, while it is interesting to note that it seems to have crystallized sometimes before and sometimes after the felspar. The mineral is most often found in the basic patches of the granite, which are no doubt derived from the fusion and subsequent recrystallization of fragments of the adjacent slate, and are especially interesting. Some are largely made up of andalusite in good crystals or somewhat rounded grains, with abundant strongly pleochroic biotite, and a certain amount of quartz, felspar, muscovite, tourmaline, cordierite, and apatite. Both the patches and the normal rock also contain numerous small zircons, generally as inclusions in the biotite, where they give rise to the usual intensely pleochroic 'halos.'

In the Tati district of Bechuanaland granite occurs as a modification of the prevailing syenite, and is chiefly remarkable for the amount of apatite it contains. I have seen crystals of this mineral from Tati nearly an inch in diameter; but in the rocks I have examined they are of purely microscopic dimensions. They show not only the usual cross-fracture, but also complete dislocation of single crystals into a number of separate fragments divided by portions of the enclosing quartz or felspar. Sphene is abundant in this rock. It surrounds the iron ores in whitish granular aggregates, which, unlike the variety leucoxene, are more or less transparent and show brilliant interference tints when the sections are sufficiently thin.

The granites of Rhodesia are notable for the abundance of microcline, which is frequently the dominant, and sometimes the only, felspar. The now well-known Matopo granite is typically composed of microcline, quartz, and biotite, with minute granules of magnetite and sparingly distributed but large crystals of brownish sphene. The Bulawayo margin of the mass is a hornblende granite with microcline, oligoclase, and orthoclase as the felspars. The accessories include large crystals of apatite, abundant yellowish sphene, a little magnetite, and sometimes a good deal of pale yellow epidote. The last-named mineral occurs in druses, and forms veins running through the granite in places. Large plates of biotite are found in the pegmatitic modifications, with microcline, etc. Fluor, malachite, chessylite, and chrysocolla occur lining cracks and joints, while molybdenite is found associated with a little secondary copper pyrites, etc., in a quartz segregation vein near Glenville, about three miles from Bulawayo. This mineral is in good crystals, thin hexagonal plates looking as if bounded by the prism and basal plane. Careful measurements of the angles give no

appreciable difference from 120°, though only two of the lateral faces appear as a rule to be normal to the basal plane. They appear, in fact, to possess orthorhombic symmetry, and to be really bounded by the pyramid, brachypinacoid, and basal plane.

Several of the granites from Northern Rhodesia contain orthite (allanite). This mineral occurs in yellowish-brown idiomorphic crystals or rounded grains, the colour being sometimes very irregularly distributed. The pleochroism is not strong, and the double refraction as a rule scarcely exceeds that of quartz. A rock from the Jibuyi River contains numerous crystals about ·5 to 1·5 mm. in length, occasionally twinned, and showing inclusions of zircon, apatite, and magnetite. The orthite is usually surrounded by epidote with more or less irregular outlines. The two minerals do not extinguish simultaneously, but that they are intergrown in definite crystallographic relation is shown by the fact that if the outline of suitable orthite crystals is taken as indicating the orientation of the surrounding epidote, the latter is found to give straight extinction. A biotite-hornblende granite from Kalomo shows zoned orthite surrounded by epidote with good crystal outline, the latter being enclosed in turn in biotite. Minute crystals of orthite also occur enclosed in the mica, where they give rise to halos which resemble but are not quite so strongly pleochroic as those which usually surround zircon. Epidote is extraordinarily abundant, and there is a good deal of sphene. A gneissose rock from the Wankie District of Matabeleland, with orthoclase crystals several inches across, presents some special points of interest. Little pink garnets and minute brown granules, which are seen under the microscope to be orthite, can be detected by the unaided eye. The garnet is in the larger grains, but the orthite is much more abundant. It is rather more strongly pleochroic than in the rocks previously mentioned. It shows zonary banding, and is frequently surrounded by biotite, but no epidote is present. The rock contains much apatite. All these orthite-bearing rocks have a distinctly gneissic aspect, which is sufficient to suggest a secondary or metamorphic origin for the orthite, even apart from its association with epidote. The presence of garnet appears to point in the same direction. It may be remarked, however, that all the rocks are exceptionally fresh, while those from Northern Rhodesia contain micropegmatite, a fact which appears absolutely conclusive as to their igneous origin. The fact of the epidote being idiomorphic towards the mica points, moreover, to its primary nature, as do the inclusions of apatite and magnetite, with zircon as well in the case of the orthite, which alone encloses recognizable crystals of that mineral. It may also be mentioned that the fine-grained modifications of the Jibuyi rock contain correspondingly small crystals of orthite, and we seem accordingly driven to regard both orthite and epidote as normal products of the consolidation of a molten magma.

V.—Contributions to Ceylon Geology: Occurrence of Corundum *in situ* near Kandy, Ceylon.

By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director of the Mineral Survey of Ceylon.

THE present notes are based on field observations made in 1900. The section described is now obscured.

Corundum is abundant in the gem-bearing gravels of Ceylon, but with the exception of the case here described no localities are known where it occurs *in situ*; the present occurrence is therefore of considerable interest, although not very satisfactory in itself.

Crystals of corundum were found in the surface soil on a piece of land known as Tenna Hena, and situated east of Kandy, and three-quarters of a mile north-east of Talatnoya bridge. The exact spot is shown in a map accompanying a paper on the crystalline limestones of Ceylon (Quart. Journ. Geol. Soc., 1903, vol. lviii, pl. xiii). A small excavation had been made, and a few pounds of corundum extracted and sold for use as emery, before my visit to the spot. All the rock exposed was decomposed, and crumbled in the fingers, being in a condition resembling sand.[1] I therefore carried on an excavation for two months, hoping to reach hard rock suitable for microscopic examination, but although a depth of about 30 feet was reached, no sufficiently hard rock was found.

At the corundum pit the 'beds' of granulite dip northwards at a high angle. A conspicuous soft yellow micaceous band 7–3½ inches wide marks the position of the sapphire-bearing zone. The sapphires occur in fair abundance in a less decomposed felspathic rock occupying a few inches on either side of this yellow micaceous band in the upper part of the shaft, but on the south side only in the lower part. The associated types of granulite are chiefly acid leptynite. The corundiferous band is about three yards from the northern boundary of a band of crystalline limestone about seven yards wide (in the lower part of the pit the distance was apparently less). There is nothing to suggest any connection between the occurrences of corundum and limestone. It is a little strange that corundum has not so far been found in the crystalline limestones of Ceylon, although so characteristic of similar rocks in Burmah.

The sapphires are of fair size, the largest about three quarters of an inch in diameter, and though of a bright blue colour, are useless as gems owing to their opacity and well-developed cleavage, and often weathered, bleached, and hydrated condition. Rhombohedral cleavage and a basal parting are alike well displayed. Combinations of the hexagonal prism and basal plane are most usual, giving a columnar aspect; the forms observed include *c* (0001), *a* ($11\bar{2}0$), *r* ($10\bar{1}1$), *n* ($22\bar{4}3$); some double crystals with basal planes inclined at

[1] It is very usual for the granulitic rocks of Ceylon to be found in this friable, sandy condition, to a considerable depth. This mode of alteration is totally distinct from the formation of laterite, nor does it appear to be due to the kaolinization of the felspars, as these are translucent, and the analysis shows that but little water is present. The change partakes perhaps rather of the nature of a physical disintegration.

a little over 90° resemble twins, but the basal planes ($c\bar{c}$) are not quite in the zone *cr*, so that this resemblance appears to be deceptive. I am indebted to Mr. L. J. Spencer, M.A., for these crystallographic details.

The soft, yellow, micaceous band consists of biotite, plagioclase (quite fresh and glassy), greenish-yellow, soft, serpentine-like decomposition-products after pyroxene (?), and minute quantities of garnet and iron-ore. An analysis (No. I) by Mr. W. C. Hancock, B.A., shows that this yellow micaceous band contains a relatively slightly larger proportion of alumina than the corundiferous rock itself.

The corundiferous felspathic rock consists mainly of orthoclase-microperthite, with also plagioclase, biotite, corundum, and small quantities of garnet, green spinel, and zircon. It is not possible to make quite certain of the total absence of quartz; a consideration of the amount of alkali which is, according to the analysis, available would indicate the presence of a small percentage of free quartz; I have not, however, been able to detect any.

The microperthite is in a very fresh condition, the plagioclase still more so. The corundum in the rock has usually a 'court' of felspar free from biotite, separating it from the remainder of the rock, consisting of felspar with scattered biotite.

Professor Sollas, F.R.S., has very kindly made a mineral analysis of the crumbled rock, with the following results:—

Heavy minerals over 3·34 (chiefly corundum)	7·6
Orthoclase, s.gr. 2·56	64·2
Oligoclase (with possibly a little quartz), s.gr. 2·65 ...	23·5
Biotite, s.gr. 2·8–2·92	4·7
	100·0

Mr. Hancock has chemically analysed the same material (No. II); No. III shows the same with water removed and ratios calculated to 100; No. IV, the molecular ratios.

	I.	II.	III.	IV.
SiO_2	47·09	58·44	59·02	·983
Al_2O_3	20·24	20·79	21·00	·210
Fe_2O_3	9·45	·58	·59	
FeO	3·04	3·85	3·89	·065
MgO	2·04	·43	·43	
CaO	3·41	2·24	2·26	
Na_2O	1·74	2·85	2·88	·192
K_2O	4·67	9·83	9·93	
H_2O	9·49	1·36	—	
	101·17	100·37	100·00	

Calculations based on the analysis show that there is a small excess of alumina (above that required for the felspars and biotite) which might be expected to have crystallized as corundum; this excess, however, is smaller than the mineral analysis would lead one to expect.[1]

[1] The presence of free quartz would raise the amount of available excess alumina, as indicated by the chemical analysis. After careful microscopic examination, however, I feel that there can hardly be any appreciable quantity of free quartz present, if any.

We have, however, in this occurrence a clear case of the occurrence of corundum (and spinel) in a member of the 'Charnockite Series' in Ceylon, in a thin zone interbanded with normal varieties of granulite. It seems more likely that in this case the presence of corundum has resulted from a local variation in the constitution of the consolidating magma than that the magma should have absorbed some rock rich in alumina of which no trace remains here or elsewhere.

The additional alumina can hardly have been obtained from the yellow micaceous band, for in that case the accompanying iron and magnesia would probably have prevented the formation of corundum; this band seems rather to have consolidated from a 'magmatic streak' which, though (like the corundiferous band) rich in alumina, contained too much iron and magnesia to allow of the formation of corundum.

VI.—River Curves round Alluvial Plains.

By T. S. Ellis.

(PAGE-PLATE XIX.)

IN the Geological Magazine for October, 1902, Dr. Callaway mentions the explanation of these curves that I gave in a paper printed twenty-one years ago. His quotation should be read with the immediate context—"These [the tributary streams] keep open a channel into which the larger stream falls." This is the essence of my argument.

Professor Phillips and Sir A. Geikie have remarked that an alluvial plain in the course of a river may be regarded as an old lake-bottom, now drained; the lake-like appearance being renewed in times of flood. Let us suppose *ABCD* (Fig. 1) to represent such an area with a river flowing through it in a straight line, and, on one side, a tributary stream, or, to use a shorter and more expressive term, an affluent, coming in at an angle. Such a condition, if it existed, would not continue even in consolidated alluvial soil; it is still less likely to have existed in the soft mud when the area was first drained. A succession of floods would certainly wash away the bank where the affluent, coming through it, had caused a break in its continuity. By this the river-bed opposite the affluent would be expanded beyond its requirements when at low water. At every flood the whole of the bed of the river and the adjoining area of land will be covered with water, the ordinary river channel being effaced. From this water suspended matter falls and forms a deposit, visible after the flood has subsided, but in greater quantity on the banks by the sides of the low-water channel than on the adjoining land. The difference is, in my view, thus explained. The water deep down in the river-bed is subjected to great pressure by that above it, so as to be, relatively to the freely moving current on the surface, stagnant. Any suspended matter in the current that falls into this relatively stagnant water sinks to the bottom, and, in the absence of current there, remains; whereas, in the flood over the land adjoining the river, there is less depth of water, and therefore less liability of the suspended matter to fall below the line of current necessary to keep it in suspension.

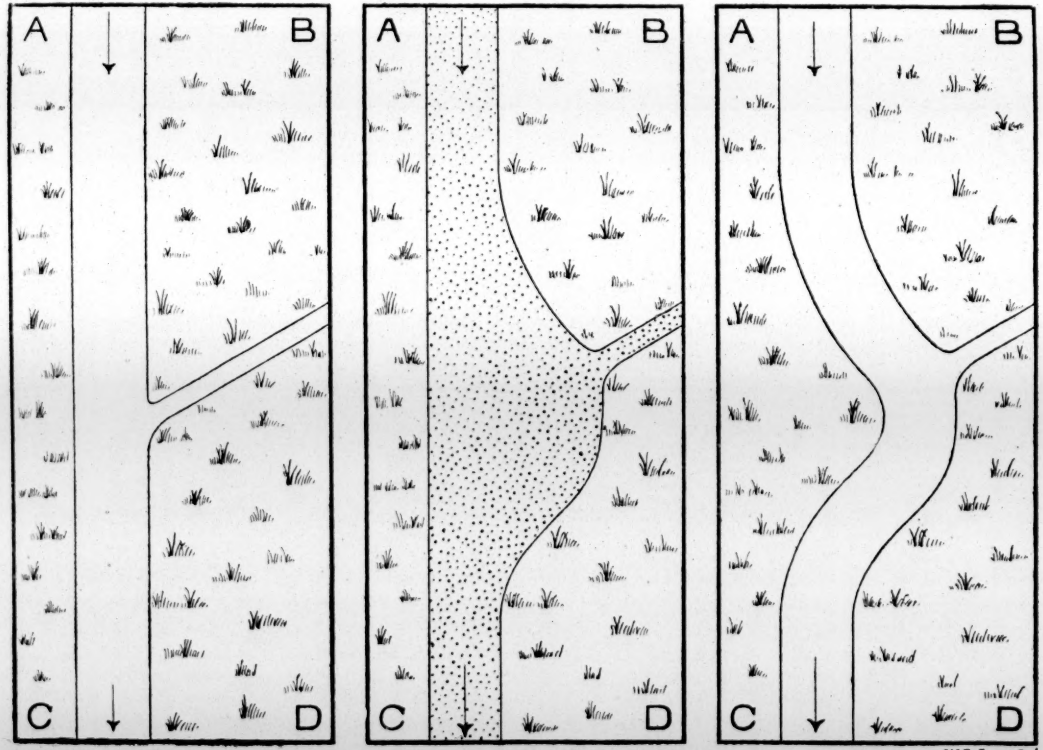


FIG. 1. FIG. 2. FIG. 3.

Diagram to illustrate Mr. T. S. Ellis's paper on River Curves.

Now we have the floor of the river channel, including the expanded portion, and that of the affluent at its mouth covered with mud, as shown in Fig. 2. When the river sinks to low water the lowest line of channel has to be determined. Clearly, a channel leading from the affluent down-stream is necessary, so that, if one for the river formed on the opposite side, there would be two. But, in fact, the river "falls into and adopts for itself" (to quote words from my paper) the channel kept open by the affluent. Hence the curve as seen in Fig. 3. The deflected river, having been directed against the bank on the affluent side, washes it away at and below the mouth of the affluent. The process being continued the river recedes, generally until the edge of the alluvium has been reached, unless some other diverting influence turns it back, while the undisturbed mud on the opposite side consolidates as it grows until, becoming covered with verdure, it forms part of the meadow on the river margin.

I am reminded that streams often wind freely where no affluents are seen. But it must be remembered that, before the area adjoining the stream became covered with grass, the surface drainage had to run direct into the stream on either side. The series of curves taking in affluents which can be seen in a brook running through the mud of a lake when the dam below has been removed illustrates this, and it is well shown in Professor Huxley's diagram of a catchment basin given in his Physiography.

An affluent is sometimes seen entering a river on the concave side of a broad curve, which must be due to some stronger influence diverting the river from it. This may be the drainage from a hill-slope, not, it may be, enough to make any one stream of considerable size, but, by flowing into the river-bed more rapidly, more effectually keeps open a river channel than the sluggish affluent flowing across the plain can do.

Sir A. Geikie considers "some slight weakness in the river-bank" to be the origin of a river curve. A breach in the continuity of any structure, be it garden wall or river-bank, involves something more than a *slight* weakness. But in the case of a river-bank a channel must be kept open from the breach seawards, which prevents the formation of any support for the bank near the affluent. Thus there is a double cause of weakness. Large sums of money have been spent in putting elements of strength into river-banks. I suggest that it might be better spent in removing elements of weakness, by uniting affluent streams and bringing them, when united, into the river at fixed points, leaving between them a long unbroken front.

Some writers allege that the influence of a side-stream is to drive the river to the opposite side. This, as it seems to me, is contradicted on every map. In my paper I likened an ordinary conjunction of two streams to a capital letter Y, where the faint upper line is in direction continuous with the lower part of the strong line. I did, however, recognize that if a stream were precipitated down the steep side of a valley with sufficient force at

right angles to another, the two would produce a resultant of direction. Still, I believe that only in exceptional cases would a river be thus diverted towards the opposite side. The rock material which such an affluent would probably bring down and throw into the river on either side of its own course (forming a 'cone') is much more likely than is the impact of stream against stream to be the real diverting influence.

Dr. Callaway, while recognizing the fact which I had pointed out, that rivers do, as a rule, bend towards their affluents, gives an explanation differing from mine. He argues that the resultant of the two streams will have the effect of carrying the principal part of the detritus brought down by the affluent across the course of the river obliquely down-stream, depositing the suspended matter near the bank on the opposite side. He regards the shoal-bank thus formed as the initial cause of the river curve. I cannot accept this. Large rivers curve which have at the convexity a very small affluent only, just enough to cut the bank down to the river-bed. It is difficult to imagine that the small amount of suspended matter which could have come down such a stream would have had any effect separate from that due to the very much larger amount brought down by the river itself. Moreover, it is at flood-time that most of the suspended matter is brought down. Then the river channel is effaced, a sheet of water covering it and the adjoining land as well as the mouth of the affluent itself. What influence could there be that would determine the dropping of the principal part of the suspended matter brought down by the affluent just within the line of the bank on the opposite side of the river? I can readily imagine that, in the swirling confusion caused by the (literal) con-fusion of the two streams, suspended matter would be likely to fall beneath the current and sink to the bottom at once, and I have seen an affluent after a flood cutting a new passage at its mouth through mud within its own banks. Nor, when the river is not overflowing, can I imagine an affluent that had just enough momentum to carry suspended matter across the stream, but not enough to injure the banks on the opposite side.

In my view, the important question is, not where is sediment deposited—it is deposited everywhere—but in what part of the river-bed is it allowed to remain? As I say, it remains where a channel is not necessary.

Professor Davis, also writing in this Magazine (April, 1903), states that "rivers cannot be habitually straight in their initial stage." Why not? An inquiry into the cause of river curves implies the supposition that, in the absence of a diverting cause, there will be no curve. This is my belief. But if "the bends with which rivers begin are as a rule spontaneously exaggerated in their later development," why not all of them? He adds that "in advanced maturity the river must always be curved." Father Thames is fairly mature, but he has long straight reaches. Theories are generally regarded as good according as they are sufficient to explain phenomena which are manifest. Can the erratic course

of the Thames be explained by any "meander system" such as that which Professor Davis expounds, or by any "curve-law" of "volume in relation to velocity" of which we often read? To me it is, throughout, a struggle between the influence of the affluents on the one and those on the other side, each, in turn, prevailing as their size or favourable circumstances may determine. If the great curve at Abingdon be not due to the influence of the river Ock and of other streams lower down, to what is it due? Can it be that the Isle of Dogs was formed "entirely independently of the action of tributaries," while we see that the Thames, in forming it, suddenly strikes southwards and takes in the Ravensbourne; then, as suddenly, striking northwards and taking in the Lea? I have not been able to examine the circumstances of every bend in the Thames, but those that I cannot understand, as seen on the map, are so few as to justify my belief that every one, from Oxford to Woolwich, admits of explanation.

My observations have mostly been made on the Severn, but I have never seen any reason to doubt the general application of the laws first suggested to me by these facts:—Above Gloucester is the "Long Reach," no affluents and a straight river; opposite the town, affluents on both sides and multiple channels, now only two enclosing the island of Alney; below the town, affluents on either side and a river with large or small curves according to the position of the affluents; in the estuary, affluents on both sides, and an ever-continuing struggle as to the extent to which either will prevail in having the principal channel on one or on the other side.

NOTICES OF MEMOIRS, ETC.

I.—On Reptilian Remains from the Trias of Elgin. By G. A. Boulenger, F.R.S.[1]

DESCRIPTIONS are given of various reptilian remains obtained by Mr. William Taylor, J.P., of Lhanbryde, in the Triassic sandstone quarries at Lossiemouth, near Elgin. Thanks to the kind permission of Dr. A. S. Woodward, the fossils were further developed in the Geological Department of the British Museum by Mr. Hall.

The remains described belong to three different reptiles.

1. *Hyperodapedon Gordoni*, Huxley.

A skull is contained in a block of sandstone, split horizontally in the plane of the palate, which is for the first time clearly exposed. The structure of the palate is seen to have been very different from what Huxley had surmised, and shows a much nearer approximation to that of *Sphenodon*. The choanæ were elongate, oval, and situated between the palatines and the vomers at some distance behind the

[1] Abstract of a paper (published by permission) read before the Royal Society of London, June 11th, 1903 (Proc. Roy. Soc., vol. lxxii, pp. 55–58).

premaxillaries. Doubts have been thrown on Huxley's interpretation of the outer toothed bone of the skull, and it is important to settle the question of its identification. The new material has convinced the author that the teeth in the upper jaw are borne by both the maxillary and the palatine as stated by Huxley. The fossil shows well the elongate rhomboidal vacuity between the pterygoid, ending at the point where they converge before diverging again towards the quadrate, to the massive anterior branch of which they are suturally united.

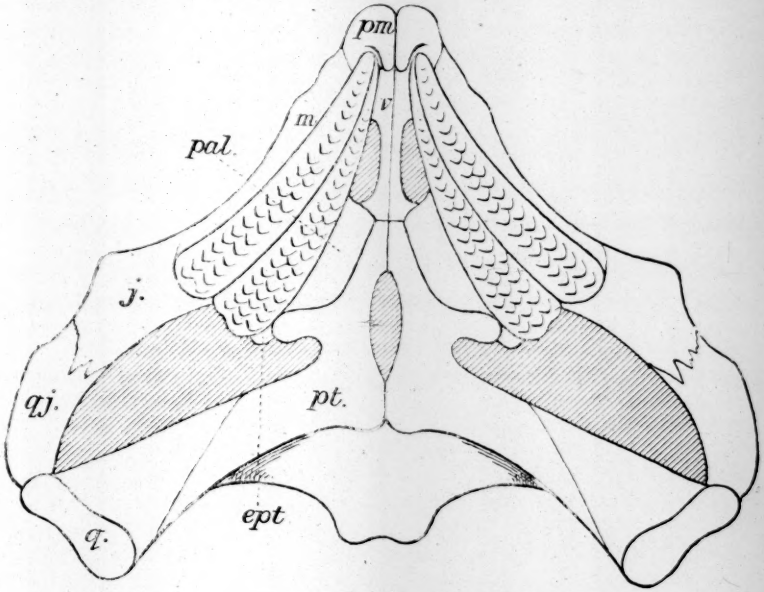


Fig. 1.—Palatal view of skull of *Hyperodapedon Gordoni*, Huxley.
ept. ectopterygoid; *j.* jugal; *m.* maxilla; *pal.* palatine; *pm.* premaxilla; *pt.* pterygoid; *q.* quadrate; *qj.* quadrato-jugal; *v.* vomer.

As may be seen from the annexed restoration, the palate of *Hyperodapedon* bears great resemblance, in its general structure, to that of the living *Sphenodon*, the principal differences, apart from the dentition, residing in the smaller bony roof of the mouth and the narrower vomers.

2. *Stenometopon Taylori*, gen. et sp. nov.

This name is proposed for a considerable portion of a skull of a Rhynchocephalian, closely related to *Hyperodapedon*, and belonging to the same family, Rhynchosauridæ. Its length is 177 mm. and its greatest width 160. One of the most striking features of *Hyperodapedon* as compared with its New Zealand ally, *Sphenodon*, is its much broader and more massive skull. The skull of the new Rhynchocephalian, although agreeing in its general structure with

that of *Hyperodapedon*, is not broader and hardly more massive than that of *Sphenodon*, from which it differs, however, very much in shape. The rostrum has quite a different direction from either of these skulls; the tusk-like premaxillaries, instead of being bent downwards into recurved processes, are directed forwards in a gradual slope from the frontal region to their extremities, which project beyond the turned-up extremities of the mandibular rami. This is practically the reverse of the condition in *Hyperodapedon*, where the strongly curved premaxillary 'tusks' are received between the outwardly directed rostral processes of the mandible. Nasal bones are absent.

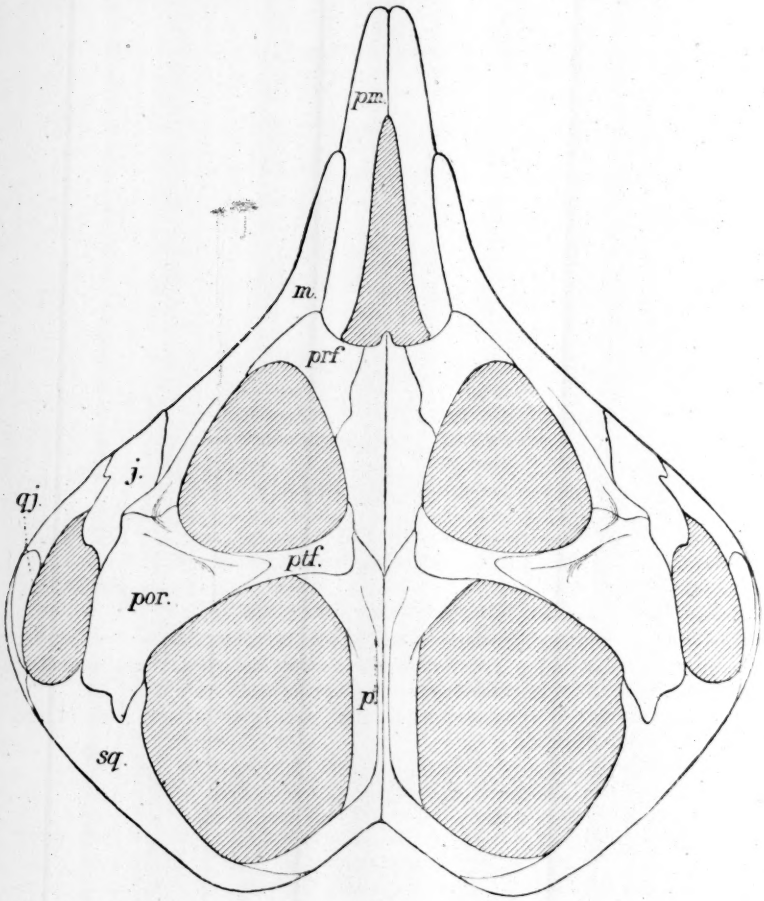


FIG. 2.—Dorsal aspect of skull of *Stenometopon Taylori*, gen. et sp. nov. *j.* jugal; *m.* maxilla; *p.* parietal; *pm.* premaxilla; *por.* post-orbital; *prf.* prefrontal; *pm.* premaxilla; *ptf.* post-frontal; *qj.* quadrato-jugal; *sq.* squamosal.

As in *Hyperodapedon*, the nasal aperture is single, but, in accordance with the shape of the premaxillaries, it is more elongate, its length being to its width as $2\frac{1}{3} : 1$; its posterior border extends to the level of the orbits, which are entirely directed upwards. The inter-orbital region is narrow, especially behind. The supra-temporal fossæ are very large, separated from the orbits by the narrow post-orbital arch and from each other by the sharp median crest of the parietals. The latero-temporal fossa is kidney-shaped, and proportionately larger than in *Hyperodapedon*, but smaller than the supra-temporal fossa. The maxillary bone is deep and nearly vertical, with an oblique ridge extending downward and backward to the jugal; the maxillary teeth, so far as they are preserved, appear very similar to those of *Hyperodapedon*, and form a single series in front and two behind. The palate is imperfectly preserved, but what is left of it agrees in essential points with *Hyperodapedon*; the palatine teeth are disposed in three series behind.

3. *Ornithosuchus Woodwardi*, E. T. Newton.

The specimen on which this species was founded by Mr. Newton in 1894 indicated a reptile about $2\frac{2}{3}$ feet long. Specimens more than twice as large are now described, and afford much information on points which remained obscure. Clavicles were present, large and widely expanded at their inner extremity, where they overlapped the inter-clavicle. A plastron, or system of abdominal ribs, was also present, resembling very closely that of *Sphenodon*, each segment being formed of a median angulate piece, to which a lateral limb is attached, the segments, however, being much more numerous and closer together than in the New Zealand reptile.

The presence of clavicles and of a plastron show that *Ornithosuchus* cannot be included among the Dinosaurs, as originally suggested, but must be placed in the order Thecodontia of Owen, which contains *Belodon* and *Aëtosaurus*. The Thecodontia should be kept distinct from the Crocodilia or Emydosauria; they agree with the latter, the Dinosauria, and the Pelycosauria, to which they are very closely related, and differ from the Rhynchocephalia, in the truly thecodont dentition; they agree with the Rhynchocephalia and Pelycosauria, and differ from the Emydosauria and Dinosauria, in the presence of clavicles, whilst they show close resemblance to the Rhynchocephalia proper in the structure of the plastron. The presence of clavicles and the condition of the pelvis, in which the pubis enters the acetabulum, together with other characters showing greater generalisation, afford ample justification for the separation of the Thecodontia or Parasuchia, as a group of ordinal rank, from the Emydosauria. The author also expresses the opinion that precision in the definition of the higher group of reptiles would gain much by the order Dinosauria being restricted to the carnivorous, truly thecodont forms, the others deserving to form an equivalent order under the name of Orthopoda, Cope (Predentata, Marsh; Ornithischia, Seeley).

II.—Description of a new species of *Matheria* (*M. brevis*), from the Trenton Limestone at Ottawa.[1] By Dr. J. F. Whiteaves, F.G.S.

THE genus *Matheria* was described by E. Billings in 1858, in the third volume of the Canadian Naturalist and Geologist. It was based upon a single species, the *M. tener* of Billings, a small lamellibranchiate or pelecypodous bivalve, from the Trenton Limestone at Lake St. John, P.Q. *Matheria* appears to be most nearly related to *Cyrtodonta* and *Vanuxemia*, and is now included in the family Cyrtodontidæ, Ulrich, of the order Prionodesmacea, Dall. The types of *M. tener*, which were collected by Mr. J. Richardson and Dr. R. Bell in 1857 at Blue Point, on Lake St. John, are still in the Museum of the Geological Survey.

A second species of this genus, from the Trenton shales of Minnesota, was described by Mr. Ulrich in 1892, under the name *M. rugosa*, in the Nineteenth Annual Report of the Geological and Natural History Survey of Minnesota. And, in his Report on the Lower Silurian Lamellibranchiata of Minnesota, published in 1897, in vol. iii, pt. 2, of the Final Report on the Geology of Minnesota, Mr. Ulrich expresses the opinion that the *Modiolopsis recta* of Hall, from the Niagara Limestone of Wisconsin and Illinois, is also a *Matheria*.

In the Museum of the Geological Survey there are a few specimens of a fourth and previously undescribed as well as unfigured species of this genus, from the Trenton Limestone of Ottawa, collected many years ago by E. Billings, and labelled by him with the manuscript name *Matheria brevis*. This species may now be defined and characterized as follows.

Fig. 1.—*Matheria brevis*. Side view of the most perfect specimen collected, in outline, and showing the marginal contour of the right valve.

Fig. 1*a*.—The same specimen, as seen from above, to show the amount of convexity of the closed valves.

Both of these figures are of the natural size.

Shell small, inflated, and regularly convex, but not quite as wide as high, suboval or oblong subquadrate, about one-third longer than high, and very inequilateral. Anterior side very short, narrow, and consisting of a small rounded lobe below the beaks on each side; posterior side longer, and a little wider in the direction of its height;

[1] Reprinted from the "Ottawa Naturalist," Journal of the Ottawa Naturalists' Club, vol. xvii (1903), pp. 33–34, May Number, Ottawa, Canada.

posterior end vertically subtruncate at its mid-height, rounding abruptly into the cardinal margin above and into the ventral margin below. Ventral margin gently convex, but curving upward more abruptly and rapidly at the posterior than at the anterior end; superior border almost straight and nearly horizontal; umbones depressed, anterior, very nearly but not quite terminal; beaks incurved.

Surface-markings not at all well preserved in either of the specimens collected, but apparently consisting of fine concentric lines of growth. Hinge dentition and muscular impressions unknown.

Approximate dimensions of the specimen figured: maximum length, 15 mm.; greatest height, 11 mm.; maximum width, or thickness through the closed valves, nearly 9 mm.

Trenton Limestone, Ottawa, E. Billings: four nearly perfect but badly preserved specimens.

M. brevis can be distinguished at a glance from *M. tener*, *M. rugosa*, and *M. recta*, by its comparatively short, tumid, and regular convex valves.

III.—The use of Carboniferous Plants as Zonal Indices. By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

THE student of Carboniferous plants has long ago realized that the kind of evidence which is drawn successfully from the distribution of marine invertebrata is inapplicable and inaccurate in the case of fossil plants. For instance, as is well known, the Jurassic rocks are divided into a number of zones on the occurrence of a species of Ammonite, confined or almost wholly confined to a particular zone. Apparently in regard to the Carboniferous mollusca, the same principle is being applied. Efforts are being made[2] to obtain one or two definite but common mollusca which occur in one subdivision of the Coal-measures, but which are absent or almost entirely absent from others, and to use such species as zonal indices. How far this will prove possible in the case of a fauna which has for the most part a wide vertical range, and which is not truly marine but largely littoral, estuarine, or even fresh-water, remains to be seen. The discovery of restricted species of plants is not, however, the primary object of the palæobotanist. Some geologists, realizing that fossil plants do not commonly afford this type of evidence, have rather hastily concluded that such remains are therefore useless as zonal indices. I hope, however, to show that this is not the case. It is true that in British rocks a number of plants are, so far as our knowledge extends, confined to one of the minor divisions of the Carboniferous, such as the Middle Coal-measures. This is the case with *Zeilleria delicatula* (Sternb.) and

[1] Abstracted from a paper read before the North of England Institute of Mining and Mechanical Engineers in June, 1903, and published in the Transactions of the Institute for the current year.

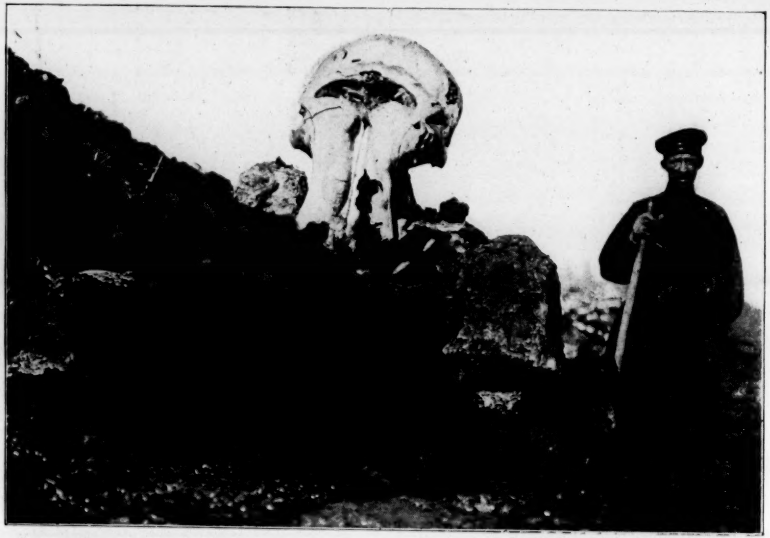
[2] "Life-Zones in the British Carboniferous Rocks: Report of the Committee": Report British Association, Bradford, 1900, pp. 340–342.

Sigillaria ovata Sauveur, plants which have recently been found in the Cumberland Coalfield. The evidence of such restricted species is not, however, the foundation of any method of zoning by means of fossil plants, although it is often important as affording confirmatory support to conclusions gained on entirely different grounds.

In order to establish the position of any bed in the Coal-measures, it is necessary to collect and to study a number of different species from it or from the associated rocks; in other words, we must know not one or two species, but a flora. The number of species need not, however, be very large. Usually twenty species or even less will suffice if they belong to diversified types of plants, but the larger the number the better. It is the relative abundance of certain types of plants at any one horizon, and the absence of other types, rather than the occurrence of particular species, which gives the solution to the problem of the horizon of the bed in question. By taking into account the aggregate or assemblage of plant types, the common occurrence of certain classes, genera, subgenera, or species, and the absence or rare occurrence of others, species which have a wide range in time in Carboniferous rocks can be made to yield evidence. Such species, despite their range, are found to be much more abundant in some of the subdivisions of the Carboniferous than in others.

Thus the common occurrence of *Lepidodendron aculeatum*, Sternb. in coal-bearing strata in itself points to such beds being of Middle or Lower Coal-measure age, rather than Upper, as this species has been found to occur most abundantly on these horizons, and less abundantly in the Upper Coal-measures. From a number of separate small conclusions of this nature a general conclusion can be arrived at, for which support can often be found from other lines of evidence, such as the occurrence of restricted species. Again, an abundance of such types of plants as *Calamites* and *Sigillaria*, in association with *Sphenopteris*, and an absence of particular types of *Pecopteris*, *Alethopteris*, and *Cordaites*, will help to distinguish a Middle from an Upper Coal-measure flora.

Occasionally small points of disagreement with a general result are found. *Alethopteris Serli*, Brongt., a characteristic Upper Coal-measure fern-like plant, is sometimes found in the Middle Coal-measures, as for instance in Cumberland. The disagreement of a single character does not, however, invalidate the conclusion drawn from an aggregate of characters. Such disagreements occur among recent plants which are classified on very similar principles to those applied here. In the recent family Scrophulariaceæ, the presence of five stamens in the flower is a single character contributing towards an aggregate of characters which distinguishes this family or natural order from others. But many, perhaps the majority of genera belonging to this family possess only four or two stamens, whereas their other characters, as a whole, clearly point to close affinity with other members of the Scrophulariaceæ possessing five stamens. It need hardly be pointed out that if all



Photograph of the newly discovered Mammoth (*Elephas primigenius*), taken *in sitû*.

Exposed by a landslip on the banks of the Beresowka, a tributary of the Kolyma, in the province of Jakutsk.

The skull was quite bare (the soft parts having been destroyed by foxes, etc.), but the body and the feet and limbs (*f*, *f*) were found still covered with the integument.

The skeleton and the skin are now both preserved and exhibited in the St. Petersburg Academy.

the plants which possess five stamens were thrown into a group founded on this one character, that group would not be a natural one, since it would include a large number of genera in no way related to one another.

IV.—A Method for the Investigation of Fossils by Serial Sections. By W. J. Sollas, D.Sc., LL.D., F.R.S., Professor of Geology and Palæontology in the University of Oxford.[1]

MECHANICAL difficulties preclude the study of fossils by serial thin slices, but serial polished surfaces may be obtained at any desired degree of proximity, and these, when the fossil and its matrix offer sufficient optical contrast, serve most of the purposes of thin slices. They may be photographed under the microscope, so as to furnish a trustworthy and permanent record. The sections may be used to obtain reconstructions of the fossil in wax. Several fossils have been successfully studied in this way, such as *Palæospondylus Gunni*, *Ophiura Egertoni*, *Lapworthura Miltoni*, *Monograptus priodon*, and *Palæodiscus ferox*. The sections are obtained at regular intervals, usually of 0·025 mm., by means of an apparatus designed for the purpose by the Rev. Jervis Smith, M.A., Reader of Mechanics in the University.

REVIEWS.

I.—The Mammoth.

(PLATE XVIII.)

1. Berichte des Leiters der von der kaiserlichen Akademie der Wissenschaften zur Ausgrabung eines Mammuthcadavers an die Kolyma-Beresowka ausgesandten Expedition. By Otto Herz. pp. 38, pls. x. Imperial Academy of Sciences, St. Petersburg, 1902.
2. Bodeneis vom Fluss Beresowka (Nord-ost Sibiriens). By I. P. Tolmatschow. Verhandl. k. russ. mineral. Ges., vol. xl, pp. 415–451, pls. v–viii (1903).
3. Osteological and Odontographical Comparison of the Mammoth (*Elephas primigenius*, Blum.) with the living Elephants (*E. indicus*, Linn., and *E. africanus*, Blum.) [in Russian]. By W. Salensky. pp. 124, pls. xxv. Imperial Academy of Sciences, St. Petersburg, 1903.

WHEN it was announced two years ago that the St. Petersburg Academy of Sciences had despatched an expedition to Siberia to obtain a newly discovered Mammoth, great interest was aroused. Previous attempts to recover a complete carcase had always ended in failure, owing to the difficulty of reaching any reported specimen in good time. On this occasion, however, it was hoped that the facilities afforded by the new trans-Siberian railway and the modern appliances of science would result in success, and at any

[1] Abstract of a paper read before the Royal Society of London, June 11th, 1903.

rate give opportunities for exact observations on a carcase in the tundra, even if the decaying mass could not be transported to a museum. The official report of the expedition published last year by its leader, Dr. Herz, showed that the most sanguine expectations of the Academy had been fulfilled. The great carcase was successfully unearthed and photographed at various stages of the work; the remains were packed with special care and speedily transported to St. Petersburg; and on reaching the Zoological Museum the material was found to have arrived in so satisfactory a state that it was not only good enough for scientific study but could also be mounted for public exhibition. The mounting has just been completed under the direction of Dr. Salensky, and the specimen is now one of the most remarkable objects of natural history in Europe. The animal is a young male of rather small size. The skeleton has been removed from the skin and surrounding soft parts, and fixed up separately on a wooden pedestal. The skin has actually been softened, prepared, and stuffed by a taxidermist, just like a modern skin; and some of its deficiencies have been hidden by mounting it in the attitude of death surrounded by the morass in which it made its final struggle. The skin of the head and ears is restored, copied from the specimen discovered and brought back by Adams a century ago. The proboscis, so far as shown, is also artificial. Some patches of wool and hair from other specimens have been added to cover bare places. Otherwise it is a genuine specimen.

Like most other carcases which have been reported, this new Mammoth was found nearly in the latitude of the Arctic Circle. It was disclosed by a landslip on the banks of the Beresowka, a tributary of the Kolyma, in the province of Jakutsk. The head was naturally exposed, and its soft parts were thus destroyed and eaten by the foxes and other carnivorous animals. The rest of the specimen, thanks to the intervention of the Governor of Jakutsk, was kept covered and intact until the arrival of the Academy's expedition. After surmounting some preliminary difficulties, Dr. Herz began to excavate backwards from the head. He first uncovered the two fore limbs, which were found in the remarkable sprawling attitude shown in his photograph (here reproduced in Pl. XVIII). Both were bent at the wrist, and clearly showed that the animal had fallen into a hole and was trying to escape. The hind limbs were then found bent completely forward beneath the body. The tongue, which was beautifully preserved, was observed to be hanging out of the mouth; and the cavity of the chest was filled with clotted blood. It may therefore be concluded that the animal was entrapped, and died from the bursting of a blood-vessel near the heart in its efforts to extricate itself.

A still more interesting fact was noted by Dr. Herz, namely, that the mouth was filled with grass which had been cropped but not chewed and swallowed. Death appears thus to have been quite sudden. The stomach was also well filled with grass, and contained no other kind of food. Dr. Herz therefore suggests that the

Mammoth may have been quietly grazing on grass-covered land which had accumulated above a glacier, when it fell into a hidden crevasse. It was found surrounded partly by ice, partly by frozen earth and gravel; and, according to the researches of Dr. Tolmatschow, the ice had undoubtedly the character of a glacier formed from snow, not formed directly from a lake or river.

Dr. Herz is not a geologist, and does not pretend to express an authoritative opinion on the geological aspect of his discoveries. A trained geologist, however, M. Ssewastianow, examined the region of the Beresowka last summer, and we may shortly expect more important observations in his forthcoming Report. Meantime, it is clear that the only mammoth-carcase of which we have adequate knowledge represents an animal which fed on grass and met its death as the result of a local accident. It did not depend for sustenance on scrub or forest-growth, as the Mammoth is sometimes assumed to have done. It cannot be regarded as lending any support to the theory of the destruction of these great quadrupeds by a flood or any unusual cataclysm.

Regarded from the zoological point of view, the new specimen is of supreme importance, and Dr. Salensky is preparing a series of memoirs upon it. The first of these, dealing with the skeleton and teeth, has just appeared, and is illustrated with numerous figures. Our only regret is that his work is not generally accessible on account of it being written solely in the Russian language.

A. S. W.

Corals and Coral Reefs in the Pacific.

II.—Memoirs of the Museum of Comparative Zoology at Harvard College, vol. xxviii.

Reports on the Scientific Results of the Expedition to the Tropical Pacific, in charge of Alexander Agassiz, by the United States Fish Commission Steamer "Albatross," from August, 1899, to March, 1900; Commander Jefferson F. Moser, U.S.N., commanding. IV. The Coral Reefs of the Tropical Pacific. By Alexander Agassiz. 4to: pp. xxxiii, 410; 236 plates. February, 1903. One volume text, three volumes plates.

IN May, 1899, Alexander Agassiz published in the Bulletin of the Museum of Comparative Zoology, Harvard College, vol. xxxiii, his account of "The Islands and Coral Reefs of Fiji," with 120 plates and 168 pages of text 8vo (see Geol. Mag., pp. 407–421).

If the earlier work formed a most valuable contribution to the literature of coral reefs, this later and larger memoir is, like the reefs themselves, 'monumental.'

Professor Agassiz reports that, "While in charge of the Expedition of the United States Fish Commission Steamer 'Albatross' during the Winter of 1899–1900 we visited the coral reef districts of the Tropical Pacific, with the exception of the Sandwich, the Samoan Islands, and the Galapagos.

"The Hawaiian Islands I had explored on former occasions, and had also obtained a bird's-eye view of the reefs of Samoa on my way to examine the Great Barrier Reef of Australia.

"It has thus been my good fortune to observe the structure of the great majority of the coral reefs, atolls, and coral islands of the tropical Pacific, and to have the benefit of the excellent charts published since the days of Darwin and Dana.

"One cannot over-estimate the great advantages to be derived from recent surveys in studying groups of coral islands like the Fiji or the Society Islands. The charts and 'Sailing Directions' contain an amount of information which no one individual could hope to bring together, and their publication has made it possible for an observer to cover an immense area and obtain within a reasonable time an insight into the structure of the coral reefs of an oceanic realm like the Pacific."

Professor Alexander Agassiz's observations and investigations on coral reefs date back to 1877 (over a quarter of a century), and have now covered the principal coral reefs and islands of the Pacific, the West Indies, and the Indian Ocean.

"The explorations" (says Agassiz) "were not continued for the sake of proving Darwin to be wrong, as seems to be the impression of some of my critics. Year after year the subject of coral reefs became more engrossing, and it was studied for its own sake. I had no theory of my own as a guiding star, nor did I attempt to uphold any one of the theories on coral reefs advanced since the publication of Darwin's 'Structure and Distribution of Coral Reefs.'"

The author gives a summary of the various and very numerous sources of information on coral reefs which he has been able to consult, including the many missionaries whose journals contain much information regarding coral reefs and islands in which they had spent years; also to the reports of voyages of English, French, and Russian navigators; he specially cites the voyage of the "Blossom" under Beechy, of the "Beagle" and the United States Exploring Expedition under Wilkes, as memorable for their reports on coral reefs by Darwin and by Dana, and on the geology of the islands of the Pacific. Agassiz also quotes the British Admiralty Surveys, and those of the French Hydrographic Bureau, as well as various minor expeditions of the United States Government.

Sir John Murray's Memoir on the "Structure and Origin of Coral Reefs" (Proc. R. S. Edinburgh, 1880) is referred to, in which Darwin's theory of the formation of barrier-reefs and atolls was discussed.

Semper's investigations in the Pelew Archipelago were carried on as far back as 1861, when he spent nearly ten months in the Pelews, and called attention (Leipzig, 1880) to the fact that all kinds of reefs (atolls, barrier, and fringing reefs) are found in the Pelews, within a comparatively short distance, in a region considered by Darwin as one of subsidence, and that at the southern extremity of the group an elevated coralliferous limestone island (Ngaur) rose to a height of over 300 feet, containing, according to Wichman, fossils of late Tertiary age. Semper lays great stress on the effects of currents between the land-rim and the barrier-reef in widening barrier-reef lagoons; and Agassiz has described reef-platform lagoons which illustrate this well.

Semper also suggests that marine animals may build up a foundation for the growth of reef-corals from far greater depths than those at which corals can thrive.

This writer also first called attention to the effect of solution in removing material from an atoll, but it is to Sir John Murray (1889–90, Proc. Roy. Soc. Edinb., xvii, p. 79) that we owe those careful experiments to determine the amount of lime removed by solution, and the suggestion of its importance as a factor in the formation of lagoons. Semper even considers the effect of solution in removing lime from the lagoon of an atoll as balancing the constructive agencies proved by the growth of corals in it.

Agassiz points out that Professor Dana was the principal supporter of Darwin's theory of the formation of coral reefs, and that the areas which these eminent naturalists and explorers covered in their investigations seemed to include all that was essential to satisfy the demands of Darwin's theory.

The author gives a summary of each important group of coral islands visited, with their chief characteristics, describing in detail the structure of the Sandwich and Samoan Islands; the Paumotu Archipelago; the Ellice, Marshall, and Gilbert Islands; the Gloucester Islands, and Marquesas; the Cook Archipelago; the Tonga Archipelago; the Haapai group to the north of Tongatábu.

"Groups like the Ellice, Gilbert, and Marshall Islands give us the means of studying the many modes of formation of the land-rims in a most satisfactory manner. Nowhere have we been able to follow as clearly the results of the various agencies at work in shaping the endless variation produced in the islands and islets of the land-rims of the different atolls of these groups; changes due either to slight elevation or to the incessant handling and rehandling of the older material in place, or of the fresh material added from the disintegration of the sea or lagoon faces of the land-rim, or of the corals on the outer and inner slopes. It has been most interesting to trace the ever-changing conditions which have produced so many variations in the appearance and structure of the islands, islets, and of the land-rims of the different groups.

"In the Fiji, as in the Society Islands, the wider fringing reef-flats often pass gradually into barrier-reefs with a narrow lagoon between the outer edge of the reef platform and the shore line. The rotten condition of the inner part of a wide fringing reef is most favourable to its removal by solution or mechanically, and leads to the formation of narrow lagoons, which may, as is the case in Tahiti, become wide and deep barrier-reef lagoons. The small number of islands and islets of the outer barrier-reef in Fiji atolls contrast strongly with the well-wooded islands and islets on the encircling belt of the Society Islands.

"The disintegration of the masses of corals growing upon a reef is due to the boring Echini, Mollusks, Annelids, Crustacea, and sponges, which infect the large masses; as these become weakened, they are torn off by the waves and rapidly reduced to shingle. The smaller fragments are then still further disintegrated by boring

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"The disintegration of the masses of corals growing upon a reef is due to the boring Echini, Mollusks, Annelids, Crustacea, and sponges, which infect the large masses; as these become weakened, they are torn off by the waves and rapidly reduced to shingle. The smaller fragments are then still further disintegrated by boring

sponges and Algæ, and by attrition on the wide reef platforms, both of the sea face and lagoon side, reduced first to coarser, then to fine sand and impalpable silt, which may be carried off in suspension. In addition to the mechanical destruction constantly going on, chemical action takes place, and water carries off in solution large quantities of lime from the sea face, where we can trace the extent of its action from the undercut faces of cliffs, of masses of corals, and the rotten condition of smaller fragments of corals.

"The same action takes place in the lagoon even to a greater extent; in every direction we can trace the effect of solution on the beach rock beaches, the conglomerate or breccia ledges, the patches of corals, the samples of the bottom, the slopes of the shoals or ledges within the lagoon, all showing that solution is a prominent factor in removing carbonate of lime from the interior of a lagoon." (p. xxiv.)

We may approximately classify the atolls, elevated islands, and volcanic islands where reefs are found, into the following categories:

Large volcanic islands with barrier and fringing reefs, like Tahiti, Viti and Vanua Levu, and the larger Samoan Islands; in these the land mass occupies a large area as compared with that of the reefs. Viti Levu and Vanua Levu, as well as Solomon, New Hebrides, and Oahu in the Sandwich Islands, are partly flanked by elevated coralliferous limestone.

Next may come smaller volcanic islands with barrier and fringing reefs, like the Pelew Islands, Yap, Truk, Ponapi, Kusaie; the smaller New Hebrides and Fiji Islands, like Nairai, Makongai, Mbengha; the volcanic islands of the Cook group, as Aitutaka, Raratonga; the Horne Islands, Rotumah, the Marquesas, and such islands as Maupiti, Bora Bora, Raiatea, Huaheine, Eimes, in which the area of encircling reefs is as large as, if not larger than, the enclosed volcanic mass.

Volcanoes like Totoya and Thombia in Fiji show the possibility of the formation of an atoll-like island by the growth of corals on the submerged or denuded rim of an extinct volcano. In Totoya the extension of the volcanic reef-rim forms a barrier-reef surrounding the island and enclosing a barrier-reef lagoon, with ship-passes into it.

Niuafóu and Tofua in Tonga are both islands with extinct craters filled with brackish water. Were the rim cut down to below the level of the sea, they would become reef-flats enclosing a deep lagoon, as is the case with a part of the rim of Thombia and Totoya.

Elevated coralliferous limestone islands, probably of Tertiary age, with limited areas of narrow reef-flat platforms, like Makatea, Niue, Nauru, Paanopa, Naiau, Wangava, with ill-defined sinks or basins occupying part of the summit.

Elevated coralliferous limestone islands, like Mango, Kambara, Tuvuthá, in which the sink is better defined, and where a volcanic outburst has broken through the rim or central part of the sink or both.

Elevated islands of coralliferous limestone, like Fulanga, Yangasá, Ongea, where the sea has eaten through the limestone rim towards the inner sink, cutting the rim into islands, and has formed a sound or lagoon dotted over with limestone outliers, forming undercut and weathered islands and islets. The encircling land-rim may disappear or be reduced to a few heads, as in Argo, Ongea, or Yangasá.

Elevated coralliferous limestone islands, cut down nearly to the level of the sea by atmospheric agencies, like Niau in the Paumotus, with a shallow sink (lagoon) connecting with the sea only through the porous mass of the land-rim, or Rangiroa, and the majority of the islands in the Paumotus, and some of the Gilbert Islands (Apamama Tapeteuea), with a lagoon enclosed by a land-rim composed of disconnected islands and islets forming passes and gaps communicating with the sea; islands all noted for the great development of buttresses of modern reef rock and of Tertiary age on the reef platforms, the remnants of a higher land mass now denuded to the level of the sea. Similar outliers in the lagoon form shoals, islands, and islets.

Extensive elevated limestone masses, like those of the Tonga Archipelago, with volcanic outbursts of limited extent that have pushed through the limestone masses.

Atolls with disconnected limestone and volcanic islands, the remnants of islands partly volcanic and partly limestone, like Guam and Eua, only on a smaller scale. In these the volcanic outbursts as well as the limestone masses have been denuded and eroded, and formed the groups of Vanua Mbalavu, Lakemba, Naitamba, Mothe, and the like.

Low atolls, like those of the Ellice, Marshall, and the Gilbert Islands in part, where the land-rim is reduced to a minimum and best developed on the weather side, and where the material composing it is subject to constant transport, the material being derived from the corals growing on the sea slope of the reef-flat platforms and from the disintegration of the slightly elevated modern reef rock conglomerate or breccia. Atolls all characterized by the great changes taking place in the extent of the islands of the land-rim, owing to the formation of sand bars, shoals, flats, bays, the closing of gaps, the filling of lagoons by sand blown in from the sea face, the throwing up of extensive dams on the lagoon flats to form secondary lagoons, the existence of reef platform lagoons; the islands on the land-rims of these atolls being flanked with coral sand, shingle, or boulder beaches on the sea face, with sand beaches or beach rock flats on the lagoon faces. The islets, shoals, and islands in the lagoons are either patches of elevated modern reef rock or knolls of growing corals, many of them with deep passes, usually most numerous on the lee side. The corals growing on the sea slope of the reef platforms are often overwhelmed by sand dunes blown over the land-rim from the lagoon flats.

Atolls, like Tarawa, Tapeteuea, and Nonuti in the Gilbert group, and Makemo, Fakarava, and others in the Paumotus, with

a well-developed land-rim on the weather-face flanked on the lee by submerged reef-flats.

Finally, such islands and islets as Tikeï, Nukutavake, and a number of small islands with central sinks and depressions formed by the beaches thrown up on the outer edge of the flat or summit of the island, leaving an open central space enclosed by the beach-dams. Similar islands occur in the Gilbert group, as Arorai and Tamana; Mejit, Lib, and Jemo in the Marshall and Nurakita, and Nanomana in the Ellice groups." (p. xxviii.)

The Ellice group is of especial interest to geologists in this country, as it was in the island atoll of Funafuti, one of this group, that the Royal Society decided to make trial borings to ascertain its structure, and Professor Sollas[1] commenced work on 21st May, 1896, a task which was continued by the Government of New South Wales,[2] under the direction of Professor Edgeworth David, F.R.S. After various trial borings, a boring 947 feet, or 147 feet below the base of the steepest cliff, was accomplished, the material passed through being coral limestone, containing numerous well-preserved corals.

Professor Agassiz has evidently felt the importance of this investigation, for he has devoted seventeen pages to a description of this atoll, and three plates and three charts to its illustration.

"All the soundings known indicate that coral reefs rise independently upon summits formed by Tertiary limestones or volcanic rocks, summits which have been formed either by elevation or submarine denudation, or upon summits of accretion forming submarine banks.

"The nature of the underlying base is naturally an important factor in determining the pitch of the sea slope; we may assume that the steep slopes of the upper part of reefs is due to the sloughing off of the limestone cliffs down to thirty or forty fathoms, much as they are sloughed off from the faces of elevated islands above high-water mark. If composed of volcanic ash or harder volcanic materials the slope in one case will be very slight, spreading rapidly laterally under the influence of the waves; in the other, the slope of volcanic material will not differ materially under water from that above high-water mark. When the slope is a talus of reef material it may lie at a steep angle or may follow closely the slope of the underlying base below the depth at which corals or Nullipores grow." (p. xxx.)

It had been Professor Agassiz' intention, he tells us, to investigate the marine fauna of each of the great oceanic groups of islands and trace the passage of the littoral into the abyssal fauna, and to obtain the material needed for a comparison of isolated oceanic faunæ to one another. Unfortunately he was unable to carry out this part of the programme.

It is refreshing to find the author expressing the opinion, that in

[1] Proc. Roy. Soc., 1897, pp. 502–515.

[2] *Natural Science*, 1899, pp. 17–37; and Proc. Roy. Soc., December, 1897, pp. 200–202.

spite of all that has been accomplished during the last 25 years towards settling the debateable points of the theory of coral reefs, *much remains to be done.*

Most important is an extensive system of boring[1] at well-selected points, to include barrier and fringing reefs and atolls in volcanic and other districts, as well as elevated coralliferous limestone islands, or islands partly limestone and partly volcanic; to be supplemented by lines of soundings and dredgings taken from low-water mark to the depths at which oceanic slopes are met.

The data thus obtained would give us the pitch of the slope of the strata underlying a barrier and a fringing reef, and of its continuation beyond the outer edge of the barrier reef.

For an atoll the bore would indicate the width of the talus, the original dimensions of the summits upon which the recent reef rock material was deposited, and the extent of lateral growth, both seaward and lagoonward. This would give a degree of precision now wanting in Professor Agassiz's recorded observations.

"On whatever side" (says Professor Sollas) "judgement may ultimately be given in the question, the thanks of the scientific world must undoubtedly be conceded to Sir John Murray for having disturbed a decided opinion from its slumber, for having awakened a fresh interest in Darwin's theory, and in thus leading to renewed investigation, which is both adding to our knowledge and suggesting fresh inquiry." (*Natural Science*, vol. xiv, p. 36.)

Of the 236 plates accompanying this great work the bulk are by the 'Heliotype' process, which is much more successful in its results than the half-tone blocks. Those plates giving views of distant reefs are only a monotone, and, as pictures, are not a success. It is possible that the lens of the camera employed was not well adapted for distant landscapes.

The near views of scenery, on the contrary, are very beautiful, and many of them most charming both for the rock-structures and the vegetation.

We heartily commend this grand work to the attention of our readers as one of the most valuable contributions yet made to the general history of coral reefs.

III.—Brief Notices.

Queensland.—Bulletin 18[2] of the publications of the Geological Survey of Queensland contains, amongst other matter, No. 180, Geological Survey Report, which is of a most interesting nature, dealing with a land of which little is known. In it Mr. C. F. V. Jackson writes a "Report on a visit to the West Coast of Cape York Peninsula and some islands of the Gulf of Carpentaria; also reports on the Horn Island and Possession Island Goldfields, and

[1] This work has been admirably carried out at Funafuti, and we are anxiously looking for the publication of the results of the examination of the cores, which has been carried out by Professor J. W. Judd, Dr. G. J. Hinde, and Dr. E. W. Skeats.

[2] For earlier notice see Geol. Mag., July, 1903, p. 336.

the recent prospecting of the Cretaceous Coals of the Cork District" (1902). Some midden heaps near Albatross Bay are noticed, from 20 to 30 feet high and stretching for several hundred yards, also large deposits of pisolitic iron-ore at the Batavia River, and some recent calcareous beds overlying Desert Sandstone of Upper Cretaceous age at Sweers Island. There is in addition much information of a general character concerning this district.

Other Queensland publications recently received are: Annual Report for 1901; Coal Beds of Waterpark Creek, by W. E. Cameron, described as Trias-Jura in age, resting on Permo-Carboniferous slates; the Kangaroo Hills mineral-field, by W. E. Cameron, 1901, mainly economic, but with a geological map on which the age of the sedimentary beds is "undetermined"; and the Burrum Coal-field, by W. H. Rands (1886) and L. C. Ball (1901), 1902, with maps and plans. Here, again, the age of the coal-bearing beds is said to be Lower Trias-Jura. Fossils are apparently scarce in species, though plentiful in numbers, but no fossils have been found in the surface rock, and its age is therefore unknown, though in places it resembles the Maryborough Desert Sandstone, which is of Upper Cretaceous age.

Melbourne, National Museum.—Mr. Frederick Chapman has, we are informed, already made great strides towards the general arrangement of this Museum. We notice that in the Proceedings of the Royal Society of Victoria he has begun the description of "New or little-known Victorian Fossils in the National Museum, Melbourne." Those described in part i, range from Plantæ to Crustacea, and include an interesting Crinoid to which the name *Helicocrinus* has been given, and a new Phyllocarid, called by Mr. Chapman *Rhinopterocaris*. A great deal may be said as to the advisability of giving local names to forms by reason of supplying a clue to their locality, but we think Mr. Chapman would be more kindly thought of if he refrained from calling any more fossils '*wooriyallockensis*'!

North of England Geology.—Bibliographies of the geology of the North of England have appeared in *The Naturalist* since 1884. The one recently published by Mr. Thos. Sheppard for the year 1900 contains some 200 entries, to the majority of which are appended short notes of contents. These local lists are of considerable value, and we should like to see a special effort made to keep them more up to date.

Petroleum.—M. Romain Zaloziecki has published "O nitrowaniu nizej wracych frakcyj ropy galicyjskiej," in *Bull. Intern. Sci. Cracovie* (Avril, 1903). This may be englished as follows: "On the nitration of fractions of Galician petroleum of which the boiling point is slightly raised." The paper is in French. A further article on the petroleum industry in Peru during 1901 will be found in Spanish in the *Boletin del Cuerpo de Ingenieros de Minas del Peru*, a new periodical of which Nos. 1 and 2 (1902) have just reached us. It is issued at Lima by the Ministerio de Fomento.

Medullosa.—Those who study fossil botany seem rather to work from a morphological than a systematic standpoint. Hence such works as Mr. Arber's "On the roots of *Medullosa anglica*" (Ann. of Botany, xvii) are of not infrequent occurrence. The first British specimens of *Medullosa*, one of the Palæozoic Cycadofilices, were described by Dr. Scott as recently as 1899. From sections of the roots of this plant, preserved at Cambridge, and which Mr. Lomax considers came from the Lower Coal-measures of Hough Hill Colliery, Stalybridge, Lancashire, Mr. Arber has been enabled to supplement Dr. Scott's very complete account. The result of this examination of fresh material has revealed a more complete knowledge of the thin-walled tissues which lie between the xylem and the periderm. The most noteworthy points are, the presence of a thin zone of phelloderm, the structure of the phlœm, and the discovery of lateral sieve-plates in the phlœm elements of both the stem and the roots. In the phlœm of *Medullosa* we have another point of agreement between it and *Heterangium*. The structure of the root of *Heterangium tiliæoides* is at present unknown, but the phlœm in the roots of *Medullosa anglica* closely resembles that of the stem in the former species. Excellent figures are given.

Peru.—Under the authority of Don Eugenio Larrabure y Unanue, Minister of Foreign Affairs in Peru, Mr. Eduardo Higginson, Consul of Peru, has issued a new map of the republic. This is not in any way geological, but will be found of great value by those who seek to localise specimens from that interesting country. The back of the map contains much printed matter of interest, and that relating to geological matters will be found under the heads of Guano, Artesian Wells, and Mineral Wealth.

REPORTS AND PROCEEDINGS.

I.—The Palæontographical Society of London.

Annual General Meeting, June 26th, 1903. — Dr. Henry Woodward, F.R.S., President, in the chair. The Secretary read the fifty-sixth Report of the Council for the year ended 31st March, 1903. It referred to the satisfactory condition of the Society, and the unusually large volume, with varied contents, which had been issued for the year 1902. This volume contained instalments of the monographs of Pleistocene Mammalia (Cave Hyæna), Cretaceous Fishes, Cretaceous Lamellibranchia, and Graptolites. The receipts were £91 3*s.* 5*d.* less than those of the previous year, and there had been several losses by death and resignation. Special reference was made to the death of the Rev. Thomas Wiltshire, D.Sc., who was for thirty-seven years Secretary of the Society. The withdrawal of several small libraries was noticed, and an appeal was made for new personal subscribers. Besides the monographs of Cretaceous and Carboniferous Mollusca, Graptolites, Cretaceous and Carboniferous Fishes, and Pleistocene Mammalia, other works were also in active progress, among these monographs of Trilobites and

Cornbrash Fossils. The officers were re-elected, namely, Dr. Henry Woodward, President; Mr. Etheridge, Treasurer; and Dr. Smith Woodward, Secretary. The new members of Council were Professor Boyd Dawkins, the Rev. J. F. Blake, Dr. Wheelton Hind, and Mr. F. W. Rudler.

II.—The Geological Society of London.

June 24th, 1903.—J. J. H. Teall, Esq., M.A., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "On a Transported Mass of Ampthill Clay in the Boulder-Clay at Biggleswade (Bedfordshire)." By Henry Home, Esq. (Communicated by Horace B. Woodward, Esq., F.R.S., F.G.S.)

The section described was exposed in the construction of a well two miles south-south-east of Biggleswade railway station. Under 10 feet 6 inches of soil and Boulder-clay, the Ampthill Clay was penetrated for 67 feet, resting on Chalky Boulder-clay, fine silty clay, disturbed Gault, and Lower Greensand. The clay is lithologically identical with the Ampthill Clay with its selenite crystals, and contains *Ammonites excavatus*, often covered with Serpulæ, but no examples of *Ostrea deltoidea*. The boulder was probably an outlier situated in Oxford Clay at a level high enough to be ploughed into by the agent which formed the Glacial Drift. The distance from which it was moved may not have been greater than a mile or two, but on this point no definite opinion can be expressed. The Septaria in it have a dip of 9°. The extent of the mass has not yet been ascertained.

2. "The Rhætic and Lower Lias of Sedbury Cliff, near Chepstow." By Linsdall Richardson, Esq., F.G.S.

The chief portion of the cliff-section described has a direction north-east and south-west; the dip of the beds not exceeding 3° to the south-south-east. The section is as follows:—

			ft.	in.
Lower Lias.		Based on a conglomerate composed of fragments of Cotham Marble	37	1
Upper Rhætic.	2.	Greenish-grey, chiefly laminated shales... ... 2 feet to	3	4
	3.	*Estheria*-bed	4 to 12	
	4.	Greenish-grey shales	3	5
Lower Rhætic.	5*a*.	Black, laminated shales	2	4
	5*b*.	Hard, blackish-blue limestone	0	5
	6.	Black, earthy shales, full of shell débris	0	6
	7.	Hard, slightly pyritic limestone	0	6
	8.–10.	Black, selenitic shales	5	4
	11.	Firm, black, thinly laminated shales	1	2
	12.	Black, earthy shales	0	6
	13.–14.	Alternating layers of sandstone and shale, the former with small quartz-pebbles	0	8
	15.	Sandstone (Bone-bed), coarse and calcareous, with masses of 'Tea-green Marl'	0	4
Upper Keuper.	I.	'Tea-green Marls' with hard bed of marlstone	10	3
	II.	Red Marls, angular fracture	56	0

3. "Notes on the Lowest Beds of the Lower Lias at Sedbury Cliff." By Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

The author examined this section in company with Mr. Richardson. The two chief points of interest are, the relation of the basal conglomerate to the Cotham Marble and White Lias of neighbouring districts, and the examination of the faunal sequence, with a view of testing the absolute value of Ammonite zones. The conglomerate resembles the so-called 'False Cotham,' and both may be explained by the breaking up of Cotham Marble, in one case at intervals during a continuous phase of deposition, in the other after the phase of deposition which produced it had entirely ceased at that place. The break thus represented in the Sedbury area may be considered to correspond roughly to the time of deposit of the White Lias in the areas to the south and east. The succession of events appears to require a tilting, the axis of rotation being a nearly east-and-west line a little south of Sedbury, with gradual and uniformly increasing depression towards the south, followed by a period of horizontal equilibrium. On the other hand, the succeeding *Psilonotus*, *Angulatus*, and *Arietes* zones indicate a gradually increasing depression towards the north with a change of axis.

A range-graph is given, showing the times of appearance and disappearance, the abundance or rarity, of several fossils within and below the zone of *Ammonites psilonotus*; and on account of the beginning of five forms at a given horizon and the disappearance of several forms immediately below it, this level is chosen as the base of the zone of *A. psilonotus*, rather than the point of appearance of *A. planorbis*, 4 feet higher up. It is hoped that the construction of range-graphs will be of use in testing the value of a series of Ammonite ages as divisions of relative time.

III.—Royal Microscopical Society.

Some Ideas on Life. Being the Presidential Address to the Royal Microscopical Society by Henry Woodward, LL.D., F.R.S., late of the British Museum (Natural History). From the Journal of the Royal Microscopical Society, 1903, ser. II, vol. xxiii, pp. 142–157.

AFTER some prefatory remarks Dr. Henry Woodward said:—Perhaps the oldest themes which are to be found broidered into the later history, legends, and traditions of all races of mankind are those which relate to the creation of the world and its inhabitants and their destruction by the Flood.

Apart from the sacred writings of the Hebrews, we have Assyrian tablets and Egyptian hieroglyphs, while the Greeks have given us in charming fables, and in many versions, the account of Prometheus forming men of clay and stealing fire from the chariot of the sun to endow them with life; of Deucalion and Pyrrha rescued from the flood, and afterwards renewing the human race by throwing stones behind them, which became men; of Epimetheus and his

wife Pandora, and the story of the sealed box, which she was forbidden to open, and how the curiosity of Pandora caused her to raise the lid, when all the evils incident to humanity poured out, and the only good remaining was Hope, which has been the solace of mankind ever since.

But leaving the regions of classical and mediæval myths, and even passing over unnoticed the earlier writers and philosophers—whose observations, though often very good, ended frequently in the fabulous and mysterious, or were intermingled with gross errors resulting from ignorance of astronomical laws and cosmical and chemical effects—we come, in 1669, to the observations of Steno, a professor of the Padua University, who compared fossil shells with recent, and showed that the two were often specifically the same—that sharks' teeth from the hills of Rome were like those of a shark now living in the Mediterranean.

The eighteenth century gave birth to many able philosophers and also to many writers having a distorted vision resulting from a firm belief in the literal acceptance of the Mosaic cosmogony, into which they constrained their facts and observations to fit.

Gesner, a Swiss observer, in 1759 demonstrated, by comparing past physical changes with those now in progress, that elevation of mountains and the wearing away of ravines and valleys must have occupied tens of thousands of years to accomplish.

Dr. John Woodward (1665–1729) insisted on the theory that all deposits resulted from the Noachian deluge, and that their materials and fossil contents were arranged by *gravitation*, the heaviest at the bottom. He did one excellent thing, he founded in Cambridge the Woodwardian chair of geology, which has now become a great centre for the teaching of modern geology, but was originally designed to ensure the delivery of a sermon annually, to confound the doctrines of Dr. Camerarius, of Tübingen, and all his works, because he differed from the views of Woodward.

Some of the writings of the Italian naturalists at this time were most brilliant and advanced, but the lack of frequent intercommunication between men of science 150 years ago prevented the wide spread of intellectual ideas.

Amongst the most able writers in this country was James Hutton (1726–1797), of Edinburgh, whose "Theory of the Earth," etc., was the foundation of Lyell's "Principles of Geology" and many other later writings. His views, based on observations, were clear and convincing to all studious minds:—

"The ruins of an older world are visible in the present structure of our planet; and the strata which now compose our continents have been once beneath the sea, and were formed out of the waste of pre-existing continents. The same forces are still destroying, by chemical decomposition or mechanical violence, even the hardest rocks, and transporting the materials to the sea, where they are spread out and form new strata analogous to those of more ancient date. Although loosely deposited along the bottom of the ocean, they become afterwards altered and consolidated by volcanic heat, and then heaved up, fractured, and contorted."

In William Smith (1769–1839) we have a man of humble origin, born at Churchill in Oxfordshire, who, by force of will and industry, trained himself and became a mineral surveyor and geologist of no mean order. He not only mapped out the geology of England and Wales in a most admirable manner, but discovered a great and original principle, which has stood the test of over 100 years of subsequent geological field-work, namely, that the relative age of sedimentary deposits can be determined with certainty by their organised fossil contents. This principle, which he was able to prove to demonstration over wide areas and in hundreds of instances, together with the excellent map which he produced, obtained for him from Sedgwick the title of "Father of English Geology." Had William Smith been as able a writer as he was a brilliant observer in the field and mapper, his name would have been more widely known than it is. One of his geological contemporaries was Samuel Woodward,[1] of Norwich (1790–1837). Suffice it to say that with a succession of men like Sedgwick, Conybeare, Buckland, Phillips, Murchison, Lyell, Scrope, Fitton, De la Beche, Griffiths, Portlock, Prestwich, Ramsay, Geikie, geology has progressed enormously in the past 100 years, and is now one of the most popular sciences of the day.

From the birth of orderly stratigraphical geology has arisen the cognate science of Palæontology, which treats of all fossil remains, and takes note of their succession in the rocks as well as their zoological position among living organisms.

But since the publication of Darwin's "Origin of Species," now forty years ago, a new and ardent school of zoologists and botanists have entered the field of palæontology, who, whilst they ignore entirely the advantage which the stratigraphical geologist derives from fossils, looked at from the chronological aspect, are nevertheless eager to possess themselves of the palæozoological evidence they furnish, which is in fact the key to open the lock of the casket that holds the secret of the origin of species, and even, they believe, of the beginning of life on the earth, a secret they are as eager to learn as that for which our first mother Eve bartered Paradise, or that which excited the curiosity of the Greek Pandora, or the unhappy wives of Bluebeard.

Although I may not deceive you with promises to disclose the very beginning of life, I may at least be able so far to lift the lid of the casket as to give you a glance at some of the earliest appearances of groups of living organisms, and point out a few which have persisted over vast periods of time, and others which, though of great importance at one time (like some of our celebrated human families), have now entirely disappeared.

While upon the subject of the evolution and extinction of life-forms I may be permitted to refer you to a very able paper which has lately appeared,[2] by Mr. C. B. Crampton, on this subject.

[1] Author of a work entitled "Outline of the Geology of Norfolk," 1833, "A Synoptical Table of British Organic Remains," 1830, and about thirty other memoirs and works.

[2] Proc. Roy. Phys. Soc. Edin., vol. xiv, p. 461; read March 20th, 1901.

I will now only venture to glance at some of the Invertebrata; leaving the Vertebrata to be discussed upon another occasion.

"In the first place" (Mr. Crampton writes) "the lowly-organised groups have persisted in spite of the gradual evolution of more and more highly-organised forms, and this must be due in large measure to their rapid growth and reproductive powers.

"That groups appear to have a shorter range in time as they acquire a higher degree of organisation.

"That living forms of groups that are dominant at the present time rarely show ancestors of such great specialisation as themselves.

"That forms that are now isolated in their zoological affinities, and bordering on extinction, are generally highly specialised in some direction, but often show signs of degeneration, and usually have ancestors of greater specialisation during some former period of dominance. A few, at any rate, seem to show a smaller degree of fertility than might be expected.

"Other forms which have come down to us from a distant period with small amount of change, or with very gradually-acquired specialisation, often show a great power of resistance to death. They are also generally extremely fertile.

"That extinct groups seem almost invariably to have acquired a great degree of specialisation during their period of dominance.

"That the more specialised genera and species of groups tend to have a shorter range in time than the less specialised, although they frequently appear to have temporarily acquired a greater dominance.

"When a group shows very quickly-acquired variation and specialisation its range is usually very restricted.

"That the later forms in extinct groups frequently show signs of degeneration, and sometimes a more primitive organisation than the most specialised forms, possibly owing their persistence to their slower specialisation.

"That long retention of primitive characteristics, or a great degree of stability and want of variation, has been usually associated with a long range in time.

"That higher groups do not spring from the most specialised forms of the parent groups before them in time, but from some generalised form in those groups which had retained a more primitive organisation." And, lastly, I would add—

That those forms which have persisted through long past periods of geological time, have also an extremely wide geographical distribution at the present day. As might naturally be expected, it is the *lowly-organised* forms which show the longest geological history.

I. Protozoa.—Radiolaria are found throughout the whole geological series and are world-wide in their distribution.

Of the Foraminifera about two-thirds out of 2,000 species occur fossil. The longevity of some genera is truly remarkable, e.g., *Lagena*, *Nodosaria*, *Textularia*. The first two range from Silurian, and the last from Carboniferous times to the present day. *Fusulina* and *Schwagerina* are world-wide in their distribution in Carboniferous time, forming entire beds of limestone. (They are, however, confined to the Carboniferous.)

Several giant species of *Nummulina* occur in early Tertiary times.

II. Porifera (the Sponges).—The Lithistid and Hexactinellid Sponges have existed since Cambrian times. The Calcispongiæ appear in late Palæozoic times, and only become important in the Mesozoic period.

III. Cœlenterata: (1) Hydrozoa.—The Graptolites are world-wide in their distribution in early Palæozoic time; they are enormously abundant and varied, and disappear at the end of the Silurian period. *Dictyonema*, a doubtful Graptolite, extends from the Cambrian to the Devonian.

(2) Anthozoa.—Of the Corals the Rugose and Tabulate corals are confined to the Palæozoic rocks.

The Hexacoralla are first seen in the Trias and continue to the present day. *Zaphrentis*, *Petraia*, *Clisiophyllum*, and *Strephodes*, all simple types of Rugose corals, range from the Silurian to the Carboniferous age. The same range is found for *Cyathophyllum* and *Diphyphyllum*, both of which are compound forms. Of the Hexacoralla four genera range from Jurassic to Recent.

Of the Tabulate corals (among the Rugosa) *Favosites* and *Syringopora* range from Silurian to Carboniferous times.

The existing corals belong to the Madreporaria, the Fungida, and Perforata, and have no Palæozoic representatives, but the Secondary and Tertiary deposits have yielded a large number of these forms. The composite Madrepora include a vast number of forms, and range from the Eocene to the present day.

IV. Echinoderma.—Of the Echinoderma the extinct groups, the Cystoids and Blastoids, only lived in the Palæozoic period. Of Cystoids 50 genera and 250 species are known, and of Blastoids 19 genera and 120 species are recorded.

The Crinoids appear to have declined ever since their maximum development in Palæozoic times. *Ichthyocrinus* ranges from the Ordovician to the Carboniferous. *Taxocrinus* has the same range. Of later forms *Pentacrinus*, *Extracrinus*, and *Antedon* have persisted from the beginning of the Mesozoic period with very little change.

Starfishes range from the Cambrian to the present day.

Echinoids: regular forms like *Cidaris* have existed since the Trias. *Echinocorys* and some other irregular forms appear in the Cretaceous, but many of the genera quickly became extinct. But both regular and irregular forms have continued on to the present time.

V. Polyzoa ('Sea-Mats').—The Polyzoa date back to the Ordovician. Of the Cyclostomata, *Stromatopora* and *Berenicea* range through the whole time to Ordovician. Many living genera range back into Mesozoic times.

The Monticuliporoids, a peculiar group, perhaps related to the Polyzoa, were dominant in Ordovician and Silurian times, but doubtfully survived the Palæozoic period.

Of the Cryptostomata such genera as *Fenestella*, *Polypora*, *Rhabdomeson*, and their allies are Palæozoic.

The Chilostomata, forming the bulk of living Polyzoa, date back to the Jurassic period.

VI. Brachiopoda. — The Brachiopoda have their maximum development in Palæozoic times. *Productus, Spirifer, Pentamerus, Cyrtia, Merista, Uncites,* and *Stringocephalus* show not only great abundance and extraordinary specialisation of forms, but also remarkable variety of shape, size, and condition of their brachial supports. They have a comparatively short range in time, both in genera and species.

The long-winged Spirifers, dominant in the Devonian, were rapidly extinguished, but the simple *Spirifer glabra* ranges from the Devonian into the Carboniferous. Any striking peculiarity of growth or size seems to be followed by rapid extinction.

In the Mesozoic period both genera and species are much reduced in numbers, the forms chiefly belonging to the persistent *Terebratula* and *Rhynchonella* types, with slight variations in their shell-markings.

With these are some exceptional forms, such as *Lyra, Magas, Kingena, Trigonosemus,* strictly Cretaceous; while a few others, as *Pygope, Dictyothyris* (specialised *Terebratulæ*), have a limited range in the Jurassic period. From the Lower Palæozoic period genera like *Lingula, Crania,* and *Discina* have continued on, and are living now. Such forms may be truly termed persistent types. In this division hermaphroditism (so rare in this class) occurs. *Lingula* shows great resistance to death, surviving after being out of water and in a dry condition for some time.

VII. Vermes (Worms).—Worms being all *soft-bodied animals* are seldom found in a fossil state. Their former existence is, however, proved by their tracks, burrows, and castings which they have left in the sedimentary rocks *from the Cambrian to the present day.* Their chitinous teeth and jaws have been exhibited by Dr. Hinde, F.R.S., before this Society, and described and figured in the Quart. Journ. Geol. Soc. London, 1879, 1880, and in the Transactions of the Royal Swedish Academy.

Many species construct tubes. These variously-formed cases (called *Serpulæ*) are common in many formations, but do not disclose much information about the structure of the animal itself.

They admirably illustrate the persistence *in time* of very simple and lowly organised forms, having bodies composed of a large number of similar segments (often capable of subdivision), and possessing moreover great powers of reparation and reproduction and resistance to death.

VIII. Mollusca. — In the Mollusca, amongst the Lamellibranchiata, there are many persistent types showing very small amount of variation. E.g., *Solenomya* has persisted since Carboniferous times, and *Nucula* from the Silurian onwards. Both belong to the 'Protobranchiata' forms, with simple gills and a sole on the foot for creeping upon—not a mere digging foot. In contrast to these are the Rudistes, such as *Diceras,* Upper Jurassic; *Requienia, Monopleura, Caprina, Sphærulites,* and *Hippurites,* etc., from the Cretaceous. These peculiar molluscs had a world-wide distribution, and occur in such numbers that beds of limestone are often built up

of their shells. *Chama*, which represents them, has continued to the present day, but is less specialised.

Trigonia is not only a persistent genus, but exhibits great resistance to extreme variation, save in minor matters of shell-ornament. It ranges from Trias to recent, and has a world-wide distribution. There are three species living in Australia, and at least 100 species extinct.

In the Scaphopoda the curious tubular genus *Dentalium* ranges from the Ordovician to the present day. There are many species, but little variation from the type.

The multivalve Chitons extend also from Ordovician times to the present, but are never common in a fossil state. Only 70 species have been described from all known horizons. They are more abundant in modern seas, more than 200 species being now living.

The Pteropods (proper) only date back to the Cretaceous. The earlier forms, known as *Tentaculites*, *Hyolithes*, *Conularia*, are very doubtfully related to the Pteropoda. We have *Tentaculites* in Silurian and Devonian rocks; *Hyolithes*, Cambrian to Permian; and *Conularia*, from Ordovician to Lias: both the latter are very persistent types.

In the Mollusca—Gasteropoda—*Patella*-like forms have existed from early Palæozoic times. Walcott has figured 6 species of *Scenella*, 8 species or varieties of *Stenotheca*, and 1 of *Platyceras*, from the Lower Cambrian of North America. *Capulus* has persisted from Cambrian times to the present day.

The remarkable genus *Pleurotomaria* also ranges from Cambrian to recent, living in Japan and in the West Indies, and is represented by 4 or 5 species recent, 11 Tertiary, 575 Secondary, and 570 Palæozoic forms.

The Nerineidæ have very specialised shells in the structure of the columella; their range is also very brief. There are 150 species recorded from Mesozoic strata.

The Pulmonifera, Land-Snails, range from the Coal-measures to recent.

Among the Cephalopoda, the Nautiloid type is remarkable for its persistence since Cambrian times. Many specialised forms, showing extreme variety of growth and shell-structure, have branched out from this stock during its dominance in Palæozoic times, but these have in turn all died out. Of these, the simple genus *Orthoceras*, with its long straight shell, had the greatest range, viz. from the Cambrian to the Trias; other forms of Cephalopod shell have fairly long ranges and show remarkable varieties of shell-structure.

The Ammonites, which range from the Trias to the Chalk, exhibit almost endless variety in shell-ornament within certain limits, and have a world-wide range in Jurassic times, branching out into more than 600 species. In the Cretaceous period (before their disappearance) they put on most singular and remarkable developments of shell-variation, *Crioceras*, *Scaphites*, *Ancycloceras*, *Helicoceras*, *Toxoceras*, *Baculites*, *Ptychoceras*, *Hamites*, *Turrilites*; then they disappear entirely. We do not know the animal in Ammonites.

The Belemnitidæ range from the Trias to the Cretaceous. The guard in most genera is large and dense, whilst the chambered portion, or 'phragmocone,' is small and rudimentary. But *Aulacoceras* of the Trias has a large phragmocone, the guard being quite small.

The Belemnites appear to have been gregarious (like their modern congeners the 'Squids'), entire beds in the Lias being composed of their guards at Whitby in Yorkshire, Lyme in Dorsetshire, and other localities in the central counties. More than 100 species have been described.

Possibly *Spirulirostra*, of the Tertiaries, and the recent *Spirula* may be survivors which have gradually dispensed with the guard to the shell, so characteristic of the Belemnites proper.[1]

IX.—The following table shows the range of the Arthropoda in time:—

ARTHROPODA.

A.—CRUSTACEA.

I. ENTOMOSTRACA. (1) Branchiopoda.

Order 1. Phyllopoda.		
	Apus	Cambrian to recent.
2. Phyllocarida.		
	Hymenocaris, *Ceratiocaris* (*Nebalia*[2])	Ditto.
	Estheria	Devonian to recent.
	Cheirocephalus	Tertiary to recent (fresh-water)
	Artemia	Ditto (saline).
3. Cladocera.		
	Daphnia and its allies	Probably all recent.
	(The *Ephippia* winter eggs of *Daphnia* have been found fossil by Mr. Clement Reid, F.R.S., in the Forest Bed series of Norfolk.)	
4. Ostracoda.		
	Cypris, *Candona*, *Cythere*, etc. ...	Palæozoic to recent.
5. Copepoda.		
	Cyclops, etc.	Not found fossil.
	Many other families are not represented in a fossil state.	

II. MALACOSTRACA.

1. Podophthalma.		
	Brachyura	Jurassic to recent.
	Macrura	Carboniferous to recent.
	Schizopoda	Ditto (*Palæocaris*).
	Stomapoda	Devonian or Silurian to recent.
2. Edriophthalma.		
	Cumacea	Carboniferous to recent.
	Isopoda	Magn. L. to recent.
	Præarcturus	Devonian (?).
	Amphipoda	Carboniferous (?).

III. GIGANTOSTRACA, Haeckel.

Trilobita	Cambrian to Carboniferous.
Merostomata.	
Eurypterida	Ditto.
Xiphosura	Silurian to recent.

[1] I am desirous to mention here that for the above summary, from the Protozoa to the Mollusca, I have largely made use of Mr. C. B. Crampton's statistics with some modifications from my own notes and other sources of information.—H. W.

[2] Recent analogue. Probable progenitor of Decapoda.

IV. CIRRIPEDIA.

(Sessile)	
Balanidæ (*Brachylepas*)	Cretaceous to recent.
(Pedunculated)	
Lepadidæ (*Turrilepas*)	Silurian to recent.

B.—ARACHNIDA.

SCORPIONIDÆ.	
(Scorpions)	Silurian to recent; world-wide distribution.
Palæophonus	Up. Sil., Scotland, Gotland, and Illinois, U.S.
Eophrynus	Carboniferous only.

C.—MYRIOPODA.

Euphoberia and allies	Coal-measures to recent.

D.—INSECTA.

Palæodictyoptera.	
Blatta	(Silurian?) to recent.
Eugereon, etc.	Permian to recent.
Orthoptera	Coal-measures to recent.
Neuroptera	Ditto.

SUMMARY.—And now, "let us hear the conclusion of the whole matter."

The whole history, since the beginning of life on the earth, shows a steady upward tendency (in fact, Evolution) in life as displayed in the Geological Record.

Extinct Groups.—Some forms appear, attain a more or less important position on life's stage, and then die out completely.

Of such are the once abundant GRAPTOLITES, which had their beginning in the Cambrian, their maximum in the Ordovician and Silurian, and then disappeared.

The TRILOBITES, which began in the Cambrian, attained their maximum in the Silurian, lived on into Carboniferous times, and then disappeared.

The MEROSTOMATA (*Pterygotus, Eurypterus, Stylonurus*, etc.) began in the Silurian, attained their maximum, lived on into the Devonian and Carboniferous periods, and then became extinct.

Persistent Groups.—Again we have *persistent forms* of which we seem to see neither the beginning nor the ending.

Of these we may name the PROTOZOA, embracing the Radiolaria and the Foraminifera, both persistent in rocks of all ages and well represented at the present day.

The PORIFERA (Sponges), which, though materially differentiated in the course of geological ages, have lived on through all time.

The Crinoidea (Sea-lilies), represented from Silurian times to the present day, but not nearly so abundant as in Palæozoic times.

The Starfishes (ASTEROIDEA and OPHIUROIDEA), both persistent types from Silurian (or earlier) times to the present.

The ANNELIDA, again, are met with in all strata and also living.

The BRACHIOPODA, beginning in the Cambrian, enormously developed in Silurian, Devonian, Carboniferous, and Secondary deposits, and still surviving in diminished numbers in modern seas.

The Mollusca, represented in past time by the persistence of

Lamellibranchiata	Cambrian to recent.
Scaphopoda	Cambrian (?) to recent.
Chitonidæ	Silurian to recent.
Pteropoda	Cretaceous to recent.
Prosobranchiata	Cambrian (?) to recent.
Cephalopoda (in part)	Ordovician to recent.
Pulmonifera (*Zonites* and *Pupa*)	Coal-measures to recent.

The Crustacea, represented in past time by persistent forms such as the

Entomostraca—	
Ostracoda	Cambrian to recent.
Phyllocarida	,, ,,
(*Xiphosura*) *Limulus*	Silurian to recent.
The Arachnida.	
Scorpionidæ (*Scorpio*)	Silurian to present day.
The Myriopoda	Coal-measures to recent.
The Insecta.	
Neuroptera	Coal-measures to recent.
Orthoptera	,, ,,
Thysanura	,, ,,
Homoptera	,, ,,

Of newer groups the following which have appeared in later geological time may be cited :—

The *Bryozoa*	Carboniferous to recent.
The *Echinoidea*, or 'Sea-urchins' ...	,, ,,
The *Gasteropoda*	,, ,,
The *Decapoda*	,, ,,
The *Isopoda*, etc.	,, ,,

If we except such groups as the Crinoids, the Brachiopods, the Nautilidæ, the Xiphosura—which evidently attained their greatest maximum in the past, and, although still surviving, are now but a feeble folk—we shall notice that the modern Echinoids, Bryozoa, Mollusca, Lamellibranchiata, Gasteropoda (Siphonostomata and Pulmonifera), the higher Crustacea (Decapoda, Brachyura, and Macrura), the Isopoda, Stomapoda, etc., and our modern Insects, are far in advance of their 'forbears' in development, and this is especially true of all the chief existing forms of life.

Just as in the vegetable world our modern flora (with its wealth of flowering plants) is far more highly organised, varied, and beautiful than the vegetation of the past ages of the world, so is the associated fauna of to-day when contrasted with that of the past.

But, it may be asked, what prospect is there of arriving at the earliest known ancestor from which all these varied forms have been derived? What help does the geological record afford us? My duty, as your guide, is to inform you that our increased knowledge of the older rocks has not shown that we are nearer the fulfilment of the young biologist's dream, and the secret of Pandora's Box remains still undiscovered. We have not as yet reached the beginning of life.

In the oldest Cambrian of North America, Professor C. D. Walcott has shown the presence of some 61 so-called genera and 142 reputed species, embracing Sponges, Corals, Annelids, Graptolites, Echinoderma, Brachiopoda, Mollusca, lowly Crustacea, and Trilobites.

But, *after all our labours and strivings* to reach the beginning of all things, let us take comfort in this, that, like Pandora of old, we still have Hope left us in the Box (or shall we say *in the Rocks*?).

Those Eozoic rocks which underlie our present oldest fossiliferous strata may yet yield to the geologist and biologist in the future an earlier and more primitive fauna and flora, just as the Lower Cambrian rocks have done for us in the past.

CORRESPONDENCE.

THE GEOLOGY OF GAVARNIE.

Sir,—The latest number of the *Bulletin des Services* (No. 93) of the French Geological Survey establishes in 300 elaborately illustrated pages a new stratigraphical paradox, confirming those already noticed in your pages. Having mapped the entire district in question on a larger scale some years ago, and having again verified the facts on the spot, I would point out the decisive features recognizable by the practical geologist.

At Gavarnie the tourist observes a gigantic precipice which is the northern edge of the Secondary and Tertiary sheet that composes the Spanish Pyrenees. Its abrupt contact with the Palæozoic rocks traversed by the entire road of approach, and the consequently sudden opposition between the character of erosion exhibited by the Cirque, excavated in the Secondary rocks, and the very different erosion of the Palæozoic, is unique in the Pyrenees.

In the *Bull. Soc. Geol.* of 1868 I first figured the fault of contact, and I have since traced its outcrop through the Cascade Hotel, the Port de Pailla, the Port Neuf de Pinede, and the Port de Gavarnie. *In front of it*, the tourist perceives a gigantic wedge of white limestones which are visibly continuous with the Devonian limestones of the Palæozoic valley in which he stands. This wedge forms the Pic Rouge de Pailla, and there contains a lead lode such as abound in the Palæozoic and are unknown in the Upper Cretaceous of the Pyrenees. Throughout its base, hollow concretions of chert and calcite abound, whose broken sections are easily confounded with Rudists and other shells; but the only authentic fossil I have found in it was a fairly characterized *Atrypa reticularis* at a few feet from the fault. The pseudo-fossils have for more than thirty years been mistaken for Rudists such as abound in the glacial blocks abundantly dispersed from the overhanging Secondary precipice. The author in question has accepted the consecrated error, and has inadvertently classed the Palæozoic wedge as a portion of the Secondary that lies beyond the fault. Inevitably, he is hence compelled to class the visible continuance of that wedge to the north as a tongue of Cretaceous extending between the granite base and the remaining Palæozoic rocks of the French valley.

His efforts to confirm the initial illusion are ingenious and inevitable. As type of the structure he imagines, he selects a section east of Gedre, where he himself admits that the Devonian limestone directly rests upon the granite. At the point he figures